VERTEBRATE DISSECTION FOR STUDENTS OF ANATOMY

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LABORATORY GUIDE TO VERTEBRATE DISSECTION

FOR STUDENTS OF ANATOMY

by

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PREFACE

The course of practical anatomy which is outlined in these pages has formed a part of the curriculum in Anatomy for the Natural Sciences Tripos in the University of Cambridge during the past five years. The experience which has been gained from its use in large classes has led to considerable modifications of the procedures recommended originally, and of the scope of the dissections. For such improvements my acknowledgements are due in the first place to Prof. Wilson and Dr Duckworth. In addition I have pleasure in making reference to contributions made by various members of the staff who have assisted in the conduct of the classes.

The scope of this dissecting manual is limited to providing the guidance required by a student in the actual dissection of the selected animals. No attempt is here made to provide the osteological instruction he requires, nor is the anatomy of the central nervous system considered beyond the few points which are advantageously introduced in the actual course of dissection. A separate course is considered more appropriate to the detailed study of neurological anatomy.

In the selection of the vertebrate types regard has been had to the probable lines of mammalian phylogeny. On this account, and in view of the extreme degree of adaptive specialisation exhibited by the teleostean fishes and birds, no example of these classes is included. These considerations are held to provide ample justification for omissions

which may seem serious, and are certainly unusual in a course of vertebrate dissection.

The various animals have been dealt with in very different degrees of detail, in view of the much greater difficulty of dissecting the smaller ones. The demands made upon the student in carrying out the dissections recommended for the lamprey, *Necturus* and the lizard have thus been approximated to the standard required for the dissection of the dogfish and dog. This has been attained by a limitation of the scope of the dissection of the three smaller types to such details as an elementary student with a fair amount of technical skill may be expected to see for himself.

The course presumes on the part of students an elementary acquaintance with the anatomy of the dogfish, frog and rabbit (or other mammal), together with a more detailed knowledge of the anatomy of some mammal. The majority of students who possess such knowledge will for the present be those who have pursued a course of human dissection, but an equivalent study of some other mammal would of course suffice. In the instructions provided for each animal, references are provided to the dissections the student will have carried out previously, with the object of encouraging him to correlate his observations with knowledge already gained. In particular, numerous references to the anatomy of the cat, rabbit and Man are provided in the account of the dissection of the dog, since one of these types will have already provided the basis of a knowledge of mammalian anatomy for most of the students. These references will serve alternatively to provide for the application of these instructions to the dissection of the cat or rabbit when these types are for any reason deemed preferable to the dog. The dissection of the dog has been

designed to serve also as an instructive commentary on human anatomy and as an introduction to the anatomical requirements of experimental medicine. References to *Scyllium canicula* have been introduced into the account of *Squalus acanthias*, since many students will already have some acquaintance with that fish.

Features which, while readily demonstrable, are not of real morphological interest or importance to the elementary student, have not been introduced. Thus a detailed study of the portal venous system of the dogfish is not invited, since it would be only of real value to specialists in the study of fish or of the venous system.

A satisfactory knowledge of the topographical anatomy of the animals is much assisted by the study of cross-sections, both thick and microscopical; but since the character of the material available will depend on the resources of a laboratory, the references to such supplementary method of study are brief.

The provision of questions at certain points in the course of dissection has been found of great value as a training in observation, and as a reminder to the student of his previous studies. It has been deemed advisable to provide answers to some of the questions: these will be found at the end of the practical instructions. Some of the questions which are left unanswered will be best dealt with by the teacher if the student cannot himself provide the answer.

The nomenclature of vertebrate anatomy presents difficulties which are due mainly to the great diversity of method by which names have been applied by workers in restricted fields. Erroneous comparisons are suggested when the same name is used for structures which are developmentally and phylogenetically distinct.

In the selection of the names employed in this manual an attempt has been made to provide a basis for a vertebrate terminology suitable for the present needs of both elementary and advanced workers.

Recent morphological advances have rendered obsolete a number of terms which have been employed extensively in the literature. I have therefore displaced these terms in favour of those which more accurately represent current views. References to authorities are provided on p. 134. Some of the alternative names with which the student is likely to meet in the course of his reading have been introduced in the text and the index.

The diagram on p. xviii is reproduced from *A Guide to the Fossil Reptiles, Amphibians, and Fishes* in the Department of Geology and Palaeontology in the British Museum (Natural History) by permission of the Trustees.

A. B. A.

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ANALYSIS OF CONTENTS

ERRATA

page 99. Six lines from the bottom, *for* "between" *read* "ventral to".

page 136. Eight lines from the bottom, No. 26, *for* "lateral" *read* "medial".

INTRODUCTION

The animals which will be dissected comprise the following: the lamprey (*Petromyzon*), the spiny (or piked) dogfish (*Squalus acanthias*), the mud-puppy (*Necturus maculatus*), the green lizard (*Lacerta viridis*), and the dog (*Canis familiaris*). They all belong to the Subphylum CRANIOTA (or 'Vertebrata'), a branch of the Phylum CHORDATA.

The CHORDATA are characterised by certain structural features, viz. (1) the dorsal position and tubular character of the central nervous system, (2) the presence of the notochord, a supporting rod placed ventrally to the nervous system and separating the latter from the alimentary canal, and (3) the presence of gill-openings from the exterior into the fore-end of the alimentary canal. In some of the more specialised of the Chordata the last two features have become suppressed to a variable extent.

The Chordata exhibit a bilateral symmetry and effect ordinary locomotion (excepting some of the more specialised forms) by means of lateral flexures of the body. They present a segmentation of the musculature (which is evidently related to this method of progression), even in those animals which have acquired some other mode of locomotion as a secondary modification.

The CRANIOTA differ from other Chordata in the presence of a head, heart and kidneys, all of characteristic structure. Cartilaginous supports along the notochord provide sites of attachment for musculature, and cartilage is also found in the head-region where it constitutes the skull. They generally form a nearly continuous column known as the

'vertebral column'. In most Craniota the cartilage becomes largely replaced by bone in the course of development.

The specialisation of the head region apparently had its basis in the evolution of certain sense-organs, viz. the olfactory organs, eyes and membranous labyrinths or otocysts (the so-called 'auditory organs'). The heart is formed on the ventral aspect of the gut and at least four parts can be distinguished, viz. sinus venosus, auricle (atrium), ventricle and conus arteriosus.

The excretory tubes form compact masses on each side of the body and are drained by a longitudinal archinephric duct on each side opening behind into the cloaca along with the alimentary canal.

The LAMPREY offers an approximate illustration of the structure of the most primitive Craniota. It is representative of one large branch of the Craniota, the AGNATHA. Animals with a similar grade and pattern of organisation are known from some of the earliest rocks (Silurian) in which animal remains have been preserved. There was even then, indeed, a considerable diversity of form among them. These early Agnatha were generally provided with a superficial armour of scales and were formerly classified (along with some fish now recognised as having affinities with the Elasmobranchii) as 'Ostracodermi'[1].

The modern AGNATHA present a few important modifications of the primitive craniote structure. The mouth is provided with a powerful suctorial apparatus, and the head-region accordingly presents certain special features. The

[1] The recent studies of 'Ostracodermi' by Kiaer and Stensiö have shewn that some of the members of that group must be regarded as Agnatha, while others are relatives of the Elasmobranch fish.

armour of bony scales or plates found in many of the early Agnatha has been completely lost.

The other large branch of the Craniota, the GNATHOSTOMATA, shews a considerable advance of general organisation which may be studied in an elementary form in the dogfish. Outstanding features of this group comprise the presence of jaws and visceral arches, and of paired appendages (fins or limbs). The latter have, however, been secondarily lost in some Gnathostomata (e.g. in snakes and eels).

Fish similar to the dogfish are known from extremely ancient rocks, viz. from the Devonian period. But it is clear that the primitive jaw-apparatus had been already considerably modified, and in the dogfish it has undergone still further change. The brain has also undergone elaboration, notably the cerebellum.

Most modern fish have undergone structural modification in reference to an extreme specialisation for an active swimming life, and the nervous system has become specialised in pattern, with a conspicuous development of those parts concerned with the sense of taste.

One kind of early fish, which differed from the dogfish *inter alia* in the possession of an air-bladder, and of bony scales in its skin and bone in its internal skeleton, gave rise in the Devonian period to a group of semi-terrestrial animals, the TETRAPODA. In these animals the paired fins of the fish had become transformed into paired limbs.

Necturus is a comparatively little modified representative of these early Tetrapoda. Most modern Tetrapoda have undergone further structural modifications, generally related in the first place to a further adaptation to the terrestrial life.

Necturus shews deviations from the structure of early Tetrapoda in the construction of the skull, and there is a considerable reduction of bony tissue in other parts of its skeleton, while no dermal scales remain; it also presents features which are related to the re-adoption of aquatic habits. An example of more extensive change is offered in the frog (*Rana*), in which there has been a fundamental change in the method of locomotion with reduction of the tail and specialisation of the hind-limbs.

In the Carboniferous (or 'Coal') period there arose a special grade of Tetrapoda distinguished as AMNIOTA. Those other Tetrapoda which are not thus included in the grade of Amniota are distinguished as AMPHIBIA.

The Amniota shew a more complete adaptation to a terrestrial life than the other Tetrapoda. The skin became suited to resist desiccation, and the course of development was modified so as to permit the laying of eggs on land instead of in water. It was no longer obligatory that the earlier part of the life-history should be spent in the water as it is with Amphibia.

The Amniota have displayed a far greater diversity of structural adaptation in different conditions of life than the Amphibia, owing mainly no doubt to their being no longer restricted for the purposes of reproduction and development to the neighbourhood of water. Extreme examples of adaptive modification in the Amniota are offered by the birds (AVES) and mammals (MAMMALIA). Those Amniota which are not thus distinguished as Aves or Mammalia are classified as REPTILIA.

The lizard (*Lacerta*) is dissected as an example of a reptile, albeit a somewhat specialised member of Reptilia. The less specialised ones have long been extinct. The lizard

shews great advances in the skeletal and muscular systems, and it is highly probable that the heart and arterial system as well as the central nervous system of the early reptiles were more like those of modern amphibians than like those of the lizard. Even the most primitive surviving reptile, the rare *sphenodon* (*hatteria*) *punctatum*, living in an island off the New Zealand coast, has advanced far from the grade of organisation seen in the earliest known reptiles.

The dog is dissected as an example of the specialised Class Mammalia. Mammalia have, however, diverged less in many respects from the early amniote structure than has the yet more specialised Group of Aves. Mammals have undergone a conspicuous development of the brain with elaboration of a special part ('neopallium') of the cerebral hemispheres for functions other than those connected with the sense of smell. The mode of locomotion has undergone some specialisation with alteration in the planes of movement of the various segments of the limbs. Most of them, moreover, are viviparous, and special adaptations of both mother and embryo are found in connection with intra-uterine gestation.

A few original works which will serve the student as an introduction to the literature of the anatomical problems arising out of this practical course are cited in the literature on p. 133.

CLASSIFICATION OF CRANIOTA (VERTEBRATA).

Subphylum: CRANIOTA.

Branch: AGNATHA.

Subclass: CYCLOSTOMATA, e.g. the lampreys.
Subclass: HETEROSTRACI, e.g. the hagfishes.

Branch: GNATHOSTOMATA.

Grade and Class: *PISCES*.

Subclass: ELASMOBRANCHII, e.g. dogfish, skates and sharks.
Subclass: DIPNOI, or lung-fish.
Subclass: TELEOSTOMI, e.g. the sturgeon, herring and perch.

Grade: *TETRAPODA*.

Subgrade and Class: AMPHIBIA.

Subclass: STEGOCEPHALIA.
Subclass: URODELA, e.g. *Necturus*.
Subclass: SALIENTIA (or ANURA), e.g. frogs and toads.
Subclass: APODA (or GYMNOPHIONA).

Subgrade: AMNIOTA.

Class: REPTILIA, e.g. the lizards and snakes, tortoises and crocodiles.
Class: AVES.
Class: MAMMALIA.

Subclass: PROTOTHERIA (or MONOTREMATA).
Subclass: METATHERIA, e.g. the opossum and kangaroo.
Subclass: EUTHERIA, e.g. the dog, cat, rabbit and Man.

GROUPING OF GEOLOGICAL PERIODS.

Eras	Periods
Palaeozoic	Silurian. (First Agnatha and Pisces found.)
	Devonian.
	Carboniferous. (First Amphibia and Reptilia found.)
	Permian.
Mesozoic	Triassic. (First mammals found.)
	Jurassic. (First birds found.)
	Cretaceous.
Caenozoic	
Tertiary	Eocene.
	Oligocene.
	Miocene.
	Pliocene.
Quaternary	Pleistocene.
	Holocene. (Recent deposits.)

RELATIVE LENGTHS OF EPOCHS

AS REPRESENTED BY THICKNESS OF ROCKS

TERTIARY. 1600 ft.
CRETACEOUS. 2500 ft.
JURASSIC. 5000 ft.
TRIASSIC. 3000 ft.
PERMIAN. 1500 ft.
CARBONIFEROUS. 12,000 ft.
DEVONIAN. 4000 ft.
SILURIAN. 7000 ft.
ORDOVICIAN. 15,000 ft.
CAMBRIAN. 12,000 ft.
PRE-CAMBRIAN. Extent unknown.

The relative lengths of time represented by these various periods differs greatly. The whole of the Tertiary epoch was probably of shorter duration than most of the preceding individual periods. It is estimated that it may have lasted about four million years, while the quaternary epoch may have comprised from a half to one million years.

One estimate of the lengths of these periods, expressed in terms of the thickness of the rocks which represent them, is provided in the adjacent chart. The rocks are here represented with the oldest at the bottom, as they would usually occur in nature.

Subphylum: CRANIOTA.

Branch: AGNATHA.

Subclass: CYCLOSTOMATA.

Genus and Species: (1) *Petromyzon fluviatilis*, (2) *P. unicolor*, and (3) *Entosphenus tridentatus*.

The Lamprey.

[n the course of your examination of this animal, attention hould be given to verifying the presence of those features vhich have already been stated to be characteristic of Chordata and in particular of the Subphylum Craniota Vertebrata). Notice also the absence of various organs vhich are present in animals of the gnathostome branch f the Craniota, viz. paired appendages (fins in the case of sh), jaws, a spleen and a definitive pancreas, and genital lucts.

The animal provided for dissection will be one of the hree named above; in addition, demonstration specimens f *Petromyzon marinus* are available. The special structures f the head involved in actuating the suctorial apparatus hould be noted, notably the displacement of the opening f the buccal hypophysis away from the mouth. The olactory epithelium becomes included in the wall of a long anal which leads to the buccal hypophysis, and the openig of this canal to the exterior thus serves as a median nostril'. This opening will be found in the lamprey on the orsal aspect of the head.

Modern Agnatha comprise (1) lampreys of various kinds, arying in length from a few inches to a few feet, and) the hagfishes, which are parasitic on fish. The latter erhaps resemble the very ancient Agnatha the more osely.

As instances of the variations of structure found in Agnatha, mention may be made of the differences in the situation of the 'median nostril' and in the number of separate gill-openings to the exterior. In the hagfishes there has been a considerable degree of reduction of the eyes, skull and brain, apparently related to their habits of life.

The lampreys differ from hagfishes *inter alia* in a peculiar modification of the pharynx which makes its appearance when the larval form of the animal (known as AMMOCOETES) becomes adult, a special respiratory portion of the pharynx being then cut off from the alimentary portion.

External Features of the Lamprey.

Can you find any scales?
Is the number of gill-slits the same as in the dog-fish?
Is the cloaca nearer the end of the tail than in fish generally? (1)
Are there any eyelids?

Observe the urinary papilla in the cloaca, and the horny 'teeth' within the mouth.

Cut through the musculature of the body-wall close to the mid-ventral line from just in front of the **cloaca** to a point just behind the level of the last gill-slit.

Cut the peritoneum in the same line, and examine the interior of the **peritoneal cavity**.

Has the gut any ventral or **dorsal mesentery**?
Can you distinguish stomach and intestine?

Remove the ventral wall of the peritoneal cavity. The **gonads** are elongated structures situated on each side of

the gut and suspended by dorsal mesenteries. Look at your neighbours' specimens in order to see examples of both sexes.

The **kidneys** (**mesonephroi**) are suspended by mesenteries laterally to the gonads. In large demonstration specimens of *Petromyzon marinus*, and in cross-sections examined with a low-power microscope, identify the **archinephric duct**, running along the ventral free margin of the kidney.

> Compare the relations of these structures with those seen in the embryos of mammals.

In the large demonstration specimens you will see the small openings ('**genital pores**') by which the ova or spermatozoa leave the body. They lead from the hinder end of the peritoneal cavity into the **urinary sinus** (formed by the united hinder ends of the archinephric ducts within the urinary papilla).

Make a small opening into the gut near its hinder end, and pass a seeker backwards to the anus.

> Does the anus open in front of or behind the urinary papilla? (2) Is this arrangement similar to that of either dogfish or rabbit? (3)
>
> Is there a falciform ligament passing between the **liver** and ventral abdominal wall? (4) and is there a gastrohepatic omentum? (5)
>
> Can you find a **pancreas** or **spleen**? (6)

Remove the skin (only) from the head, including the whole of the branchial region. Ventrally, the cartilaginous **branchial basket** will be found covered by a thin layer of **hypobranchial musculature**. Dorsally, musculature extends forwards above the gill-openings as **epibranchial**

musculature. Behind the branchial region the distinction between these two portions of the musculature disappears. Between them in the branchial region is exposed pharyngeal musculature around the gill-openings. The branchial basket is continuous behind with a cartilaginous sac enclosing the **pericardium.**

Open the pericardium just sufficiently to see into its cavity. The septum separating it from the peritoneal cavity is known as the **septum transversum.** To the hinder surface of the latter is attached the liver.

> Do you recognise divisions of the heart corresponding to those of the selachian heart? (7)

Follow the ventral aorta forwards. Before carrying out this dissection the course of the vessel should be studied in a series of sections.

> Does the ventral aorta pass dorsally or ventrally to the 'rasping organ' or 'tongue' which actuates the suctorial apparatus of the mouth? (8)

In the microscopic sections provided follow the **anterior cardinal veins** forwards to the neighbourhood of the **hypophysial sac**, and the posterior cardinal veins backwards to the tail, where they join to form the **caudal vein.**

Insert the point of the scissors into two adjacent gill-openings and cut through the intervening septum. Examine the interior of a **branchial pouch**. *Open* in a similar way all the pouches on one side of the animal. *Scrape* away the gills which clothe the interior of the pouches, and carefully *remove* the medial walls of the pouches so as to lay open the **respiratory pharynx**. The lumen of the pharynx will be recognised by the coming into view of the pharyngeal openings of branchial pouches belonging to the other side.

Open the intestine a short distance caudal to the heart, and pass a narrow seeker along the gut towards the mouth. Observe that it passes dorsally to the respiratory pharynx. Find its anterior opening.

Does the respiratory pharynx end blindly behind? (9)

In sections of a larval lamprey (Ammocoetes) ascertain that the pharynx is as yet undivided into respiratory and alimentary portions; identify the **endostylar groove**.

Can you see any glandular tissue in its side-walls?

Pass a seeker down the hypophysial canal ('median nostril').

Does it communicate with the pharynx? (10)

The dark structure immediately behind the 'median nostril' is the **nasal sac**. Verify that it opens into the hypophysial canal. The **brain** is immediately behind the nasal sac.

Is there a cartilaginous cranial roof over any part of the brain? (11)

Remove the tissues superficial to the brain and examine its dorsal surface. Identify the **medulla**, **optic lobes** (there is a **chorioid plexus** in the roof of the mid-brain between them), **paired cerebral hemispheres** each of which is partly divided by a superficial groove into anterior **olfactory bulb** and posterior **olfactory 'lobe'**. Draw the dorsal aspect of the brain *in situ*.

What differences do you observe from the brain of the dogfish?

Make a dissection of the larger cranial nerves. The **vagus** will be found leaving the brain immediately behind the

level of the auditory capsule, and the trigeminal nerve just in front of it.

> Does the cranium extend caudally beyond the site of exit of the vagus from the neural canal? (12)
>
> What structures occupy the fore-end of the head?

In microscopic sections examine the **pineal** and **para-pineal organs**, the **habenular ganglion, cerebral hemispheres, optic nerves, chorioid plexuses, trabecular cartilages** forming the base of the cranium; **retina** of the eye; **semicircular canals** (how many does each membranous labyrinth possess?) (13); olfactory organ.

Examine the structure of the body-wall, and notice the shape of the myotome between two adjacent **intersegmental septa (myocommata)**.

> Is there a horizontal **myoseptum** separating epaxial and hypaxial musculature as there is in the dogfish? (14)

Remove the musculature of a few adjacent segments and expose the **notochord**. Dorsally to the notochord the cartilaginous vertebral elements (**arcualia**) can be felt rather than seen.

Subphylum: CRANIOTA.

Branch: GNATHOSTOMATA.

Class: *PISCES.*

Subclass: ELASMOBRANCHII.

Order: SELACHII.

Group: *EUSELACHII.*

Suborder: SQUALI.

Genus and Species: *Squalus acanthias.*

The spiny or piked dogfish.

Dogfish and sharks, skates and rays belong to the more specialised section of the Order Selachii, and are distinguished as Euselachii. More primitive Selachii—the Protoselachii—should be studied in the Museum, viz.

(*a*) *Cestracion,* a modern representative of a once extensive Suborder, the Heterodonti;

(*b*) *Heptanchus*, *Hexanchus* and *Chlamydoselache*, of the ancient Suborder Notidani.

In addition, representatives of the Holocephali, another Order of Elasmobranchii, should be examined, viz. *Chimaera* and *Callorhynchus*. They retain various primitive features while presenting specialisation of the teeth and concomitant fixation of the upper jaw.

Remains of Euselachii have been found in deposits of the Carboniferous period. By the time we come to the Mesozoic era there had already occurred great divergence of structure within the Group, for the flattened forms (Suborder Raji) were already distinct from the more spindle-shaped Squali. At the end of the Mesozoic period various modern genera had become distinct; *Scyllium*, the true dogfish, and *Squalus* were already differentiated by the Cretaceous.

Elasmobranchii belonging to Orders other than that of the Selachii have been found in rocks as old as the Silurian.

The evolution of the Euselachii was characterised chiefly by a specialisation of the jaw-apparatus with an alteration in the movements of the upper jaw. Among the Notidani of to-day the jaw-suspension and jaw-movements which were general among the Palaeozoic Elasmobranchii may still be seen.

The Euselachii have diverged among themselves mainly in the following respects:

(*a*) Flattening (in Raji) of the whole body, and expansion of the pectoral fins with reduction of the tail, dependent on a change in the mode of progression.

(*b*) Alterations in the form and arrangement of teeth.

(*c*) Divergent developments of the calcification pattern in the vertebral column.

External Examination.

Notice external differences from the true dogfish, *Scyllium*. The skin is comparatively smooth. Rub the skin from behind forwards, then from before backwards. Dorsal fins have large spines in front of them.

> Is there a pair of oronasal grooves as in *Scyllium*? (1)
>
> Is there an anal fin? (2)
>
> Are there any scales?

Compare external features with the lamprey, and with the frog.

> Is the dorsal fin of *Squalus* continuous? (3)
>
> Is the cloaca relatively further from the end of the tail than in the lamprey?

Is the tail-fin symmetrical? The shape you see in *Squalus* is known as **heterocercal**.

Are there any eyelids? Notice the extensive **conjunctival sac**. What do you think is the functional significance of this?

Where do you find the openings of the nasal sacs? Probe them. Do they communicate with the oro-pharyngeal cavity as in Tetrapoda?

Compare the number of gill-slits with that seen in representatives of the Notidani in the Museum. The spiracle is retained in *Squalus* and most other primitive fish.

Did you see spiracles in the lamprey? (4)

Is there any vestibular space, separating the alveolar margin of the lower and upper jaw from a **lip**?

At the angles of the mouth will be seen deep recesses, the **paralabial fossae**, when the mouth is closed. They disappear when the mouth is opened wide; the angles of the mouth are then supported by the **labial cartilages**, which can be felt through the skin.

Remove one of the fin-spines.

Is it attached to the vertebral column? (5)

What occupies its hollow interior?

Find the openings of the **endolymphatic ducts** between the spiracles, near the mid-line. These openings close in the course of development in most Craniota.

Observe the **lateral line**, marking the situation of the lateral-line canal in which are situated sense organs stimulated by low-frequency vibrations. Make a section of the body in the tail region, if this has not already been done, and identify the canal.

This lateral-line canal system is continued on to the head.

Observe the distribution of **mucous pores** on the head; they lead into the **ampullae** of Lorenzini, sense organs which along with those of the lateral line are grouped as **neuromast organs**. Make a deep incision into the side of the fore-end of the snout, and examine the canals leading from the pores to the ampullae and the terminations of nerve-bundles on the ampullae.

Remove the skin from the entire surface of the head, including the branchial region. This is best effected by strong tension combined with the use of the scalpel on the deep aspect of the skin. Care will be necessary in certain places, since pharyngeal constrictor musculature is attached to it (*a*) on a level with the lateral line, above the branchial region, (*b*) around the gill-slits, and (*c*) dorso-caudal to the spiracle. Care must also be taken not to injure the **hyomandibular division** of the **facial nerve** immediately caudal to the spiracle.

Extending backwards from the skull, medial to the branchial apparatus, will be seen **M. dorsalis trunci (sacrospinalis)**.

Between the margins of the lower jaw (Meckel's Cartilages) identify the **ventral constrictor muscle**. It extends caudally over the lower aspect of the pharynx.

Remove the upper wall of the conjunctival sac, and separate the eyeball from the overhanging **supraorbital crest**. Posteriorly, this ends in a lateral projection, the **postorbital process**. It is to this process that the **adductor process** of the upper jaw is articulated in *Heptanchus*. Identify the adductor process of the upper jaw (palatoquadrate bar) immediately lateral to the spiracle.

Cut away the postorbital process and supraorbital crest

from the cranium. The former will be found to give origin by its lateral extremity to an aponeurotic band which joins the large **adductor mandibulae** muscle; the latter covers the articulation of upper and lower jaws just below the spiracle.

Disappearing beneath the upper margin of the adductor mandibulae muscle will be seen the **afferent pseudobranchial artery**[1]. Crossing superficially to this artery and then passing on to the surface of the adductor mandibulae muscle, will be seen the **external mandibular nerve** (anterior division), which is distributed to neuromast organs. Leaving the hyomandibular nerve at the same point as this portion of the external mandibular nerve is the **internal mandibular nerve**. This nerve passes downwards and backwards to disappear at the upper margin of the adductor mandibulae. It here passes between the **ceratohyal** and the lower jaw to the mucous membrane of the floor of the mouth. It is probably represented in mammals by the **chorda tympani**. The hyomandibular nerve will be seen to end at the caudal side of the adductor mandibulae by dividing into the large posterior division of the **external mandibular nerve**, and the smaller motor **hyoid nerve**, which disappears under cover of the lateral margin of the ventral constrictor and supplies a part of it.

Just anterior to the spiracle recognise **M. compressor spiraculi anterior**, which is in this fish scarcely differentiated from the **levator palatoquadrati**[2] just anterior to it. Both disappear deep to the adductor process

[1] The name 'hyoidean' which has sometimes been applied to this artery in unsuitable since it is formed as a commissural vessel between the embryonic mandibular artery and the efferent hyoidean artery.

[2] Luther's and Lakjer's name. This muscle has been frequently named the 'levator maxillae', even in cartilage fish. In view of the absence of a maxilla in these fish, the name is inappropriate.

of the upper jaw, and are attached to the upper jaw. By comparison with a cleaned skull ascertain the exact site of attachment of these muscles.

Pass an instrument into the first gill-slit and examine the extent of the branchial chamber.

> Has it an elongated or a short opening into the pharynx?

It possesses a lateral wall supported by branchial rays, and covered superficially by a part of the **dorsal constrictor muscle.**

> Are these rays articulated to both hyomandibular and ceratohyal cartilages?
>
> What do you think is the action of the dorsal constrictor muscle?

In front of this muscle, and distinct from it only at its lower attachment is the **hyomandibular muscle**, which passes deep to the hyomandibular nerve and gains attachment to the distal end of the hyomandibular cartilage deep to the afferent pseudobranchial artery. Anteriorly a small portion of this muscle has been differentiated with a distinct insertion on the upper jaw, the M. compressor spiraculi posterior. Follow the afferent pseudobranchial artery caudally.

> Whence does it derive its blood?

Find the afferent artery of the hyoid arch.

Examine the attachment of M. levator palatoquadrati to the upper jaw. Lying on the jaw, adjacent to this attachment, is the **mandibular nerve**, and, just anterior to the nerve, the **orbital artery**[1]. The colour of the injection in

[1] Carazzi's name (*Anat. Anz.* 1905). This artery has been sometimes named the 'external carotid'; but it is not homologous with the artery of that name in the Tetrapoda.

this artery indicates that it receives its blood from the efferent and dorsal aortic system of arteries. It will be subsequently followed to its origin from the **internal carotid**, beneath the auditory capsule.

Under cover of the anterior margin of M. adductor mandibulae the mandibular nerve will be seen to divide into two branches, a posterior motor branch which enters the adductor mandibulae and supplies it, and an anterior branch which passes round the hinder aspect of the paralabial fossa to reach Meckel's cartilage. It supplies skin and the fore-part of the ventral constrictor muscle.

> In reaching the latter does it pass superficially or deep to Meckel's cartilage? (6) Is this course comparable with that of the nerve to M. mylohyoid in Man?

Forming the medial wall of the paralabial fossa is the tendon of the **orbital head** of M. adductor mandibulae. Find the nerve to it from the mandibular nerve (leaving the latter as it crosses the upper jaw). Compare the arrangement of the branches of the mandibular nerve in the dogfish and Man.

Remove the main portion of the adductor mandibulae muscle, taking care not to injure the internal mandibular nerve at the supero-caudal margin of the muscle. Notice its exact sites of attachment on the jaws. Retain the orbital head of the muscle for the present.

> What do you think is the functional significance of the adductor process on the palatoquadrate bar?

Ascertain that the internal mandibular nerve passes between the ceratohyal and Meckel's cartilage.

Define the capsule of the jaw-articulation.

Follow the afferent pseudobranchial artery forwards deep to the insertion of M. compressor spiraculi posterior (*detach* the latter from its insertion on the jaw), and then as far as its termination in the **spiracular hemibranch**. From this hemibranch the **efferent pseudobranchial[1] artery** passes inwards on the anterior wall of the spiracle. Expose it by making an artificial separation between the Mm. compressor spiraculi anterior and levator palatoquadrati, and *remove* the former.

The Orbitotemporal Region.

Define the interval between the orbital perichondrium and the eyeball.

> Does the soft tissue between the eyeball and the orbital wall appear to be of a fatty character, as it is in Man?

Identify the **lateral, superior** and **medial recti**. Examine the origins of the two latter from the skull, and find the **superior division of the oculomotor nerve**, dividing immediately it enters the orbit, to supply these two muscles. Notice the absence of any M. levator palpebrae superioris.

At the upper part of the medial wall of the orbit identify the **superficial ophthalmic nerve**, a compound nerve with contributions from both the trigeminal and facial nerves.

> In *Scyllium* do these contributions enter the orbit by the same foramen? (7)

[1] This artery (in *Cestracion*) represents the dorsal part of the embryonic mandibular aortic arch (de Beer). It has also been termed the 'anterior carotid'.

Immediately beneath this nerve will be seen the **trochlear nerve**, passing from the cranial wall to the **superior oblique muscle**.

> Has the latter any pulley on the orbital margin as in Man? What do you think is its action?

Identify the thin **fascia bulbi** (Capsule of Tenon) surrounding the eyeball. Passing between the superior and lateral recti, and then below the former, is the **deep ophthalmic nerve** (N. ophth. prof.). Close to the eyeball it gives off fine **ciliary nerves**.

> Does the deep ophthalmic nerve leave the orbit anteriorly by the same foramen as the superficial ophthalmic nerve?
>
> Does the deep ophthalmic nerve pass above or below (*a*) the medial rectus, (*b*) the superior oblique muscle?
>
> Have you seen any similar deep ophthalmic nerve in *Scyllium*? (8)

Observe the course of this nerve in the demonstration specimen of the skate.

Ascertain the respective distributions of the deep and superficial ophthalmic nerves.

> Which of them appears to follow a course more like that of the 'ophthalmic division of the trigeminal nerve' of Man?
>
> From which part of the cranium do the Mm. hyomandibularis and compressor spiraculi posterior take origin?

Remove these muscles, taking care to avoid injury to the hyomandibular nerve.

What do you think would be the action on the jaw-apparatus of M. hyomandibularis? (compare your dissection with a cleaned specimen of a skull).

Deep to M. compressor spiraculi posterior is a thin-walled space, the **vena capitis lateralis** ('primary head vein', or 'anterior cardinal vein').

Observe that it passes deep to the hyomandibular muscle.

Is it also deep to the articulation of the hyomandibular cartilage with the auditory capsule?

It passes medially to the spiracle and enters the orbit. Immediately in front of the first gill-slit it receives a large hyoidean vein.

Detach M. levator palatoquadrati from the auditory capsule, and as you do so identify the nerve supplying t. *Remove* the muscle. Follow the efferent pseudobranchial artery as far as the mandibular nerve.

Does this artery pass superficially or deep to the orbital artery? Do they communicate? (9)

Cut completely through the upper jaw in front of the site of insertion of M. levator palatoquadrati, where the mandibular nerve crosses it, taking care not to injure the internal mandibular nerve, the mandibular nerve, or the subjacent mucous membrane of the mouth and spiracle.

Turn the hinder part of the upper jaw downwards and outwards, cutting, if necessary, the palatomandibular ligament which is attached to the upper jaw close to the site of section.

Which jaw articulates with the hyomandibula?

Remove the hinder portion of the upper jaw (palato-

quadrate bar). Find the ligament which extends from the hyomandibula to the lower jaw. Identify the **posterior palatine**[1] (pretrematic or prespiracular) branch of the facial nerve which passes laterally beneath the efferent pseudobranchial artery, next the mucous membrane just where the spiracle enters the oropharynx and slightly more caudal than the mandibular nerve.

Detach the superior and medial recti and the superior oblique muscle from the eyeball. Identify the **ophthalmic artery** which enters the eyeball posterior to a cartilaginous **pedicle** against which the eyeball rests.

> Does the optic nerve enter the orbit amidst the origins of the orbital muscles as in Man?

Cut the optic nerve. Turn the eyeball downwards and outwards. *Detach* the **inferior rectus** and **inferior oblique** from the eyeball, and ascertain the distribution of the inferior division of the third nerve.

Remove the eyeball, and put it aside for subsequent examination under water, when the following points should be investigated:

> Does the surface of the cornea appear to be more or less convex than in Man?
>
> Is the lens more flattened or more spherical than in Man? Do you think that these differences are related to life in an aqueous medium?
>
> Is there an iris?

[1] This nerve has been sometimes erroneously described as the 'chorda tympani', implying a homology with the nerve to which that name is given in the mammals; *e.g. The Cambridge Natural History, Fishes*, by T. W. Bridge, 1904. It is, however, not homologous with the mammalian nerve of that name (Norris and Hughes, *Journ. Comp. Neurology*, **31**, 354). The internal mandibular nerve (*vide supra*, p. 11) is probably correctly regarded as the representative in fish of the chorda tympani.

Identify the buccomaxillary ('infra-orbital') nerve passing forwards, below the nerve to the inferior oblique muscle.

> Does the arrangement of the third (oculomotor) nerve in superior and inferior divisions in the dogfish correspond to the divisions recognised in Man? (10)

Examine the origin of the orbital head of the adductor mandibulae muscle, and the course pursued by the orbital artery in the orbit. On the medial wall of the orbit, find the upwardly directed **orbital process**[1] of the upper jaw, on the medial side of the superficial ophthalmic nerve.

> Have you seen a similar process in *Scyllium*?
>
> How would the existence of these processes on the upper jaws affect its movements?

Follow the posterior palatine branch of the facial nerve medially, beneath the efferent pseudobranchial artery. It will be seen that it is the posterior branch of a **palatine nerve** which divides almost immediately it leaves the auditory capsule. Follow the anterior division of this nerve forwards to the oral mucous membrane.

> To what branch of the human facial nerve does the (anterior) palatine nerve appear to correspond? (11)

Examine the distribution of the buccomaxillary nerve. It supplies not only skin but neuromast organs. *Divide* this nerve and the mandibular nerve.

Remove the anterior portion of the upper jaw (the hinder part has been already removed) according to the following procedure:

[1] Sewertzoff's name (*Journ. Morph.* 38, 1923). It is also known as the 'palatal' or the 'palato-basal' process.

Separate the two upper jaws at their symphysis, working from the oral aspect. Cut through the oral mucous membrane along the oral and labial sides of the upper jaw on the one side. From the orbital aspect, remove the orbital head of the adductor mandibulae and extract the fragment of jaw.

Examine the further course of the efferent pseudobranchial artery. Find the origin from it of the ophthalmic artery, and the entrance of the former artery into the cranial wall, where it will be followed later.

Follow the palatine and hyomandibular nerves to the auditory capsule.

> Do they emerge by the same foramen? (12)
> Does the orbital artery pass through or entirely below the auditory capsule? (13)

Identify the foramina for nerves and for the efferent pseudobranchial artery on a cleaned skull. Find the groove for the **vena capitis lateralis**. Ascertain from reference to your dissection what passes through the foramen situated behind that for the efferent pseudobranchial artery and below that for the oculomotor nerve (14). Follow the vena capitis lateralis forwards and establish its continuity with the **orbital sinus**, beneath the mandibular nerve.

Find the **abducens** (sixth cranial) nerve.

> Does it gain the orbit by means of a foramen distinct from that for the trigeminal nerve?

Postcranial Region of the Head.

Carefully detach the dorsal edge of the dorsal constrictor musculature from the surface of M. dorsalis trunci, and with

the handle of a knife open up the space between the branchial apparatus and the dorsal muscle-mass. In this interval will be found the capacious **anterior cardinal sinus**. Crossing the floor of this sinus will be seen **efferent branchial arteries** (how many?) and **branchial** branches of the **vagus**. The latter are seen dividing into their **pretrematic** and **posttrematic** branches, destined respectively for the anterior and posterior aspects of the various gill-slits. The walls of the first gill-slit are innervated from the glossopharyngeal nerve, which will be dissected subsequently.

Each efferent branchial artery will be found to be formed by the union of pretrematic and posttrematic branches.

Find the origin of the **lateral-line** branch of the **vagus**, which leaves the main nerve just behind the skull and disappears into the dorsal muscle-mass. It passes between the **dorsalis trunci muscle** on its medial side, and the **rectus abdominis lateralis** on its lateral side.

Remove the skin covering the pectoral girdle and fin, and remove the skin from the posterior wall of the first gill-slit.

On each side of the mid-ventral line there is a large muscle extending forwards beneath the pharynx from the pectoral girdle. These are the **Mm. coracoarcuales communes**.

The ventral constrictor will be seen to be attached to the pectoral girdle laterally to the coracoarcualis communis, while the dorsal constrictor muscle has a broad attachment to the girdle near its dorsal end, the part so attached constituting a rudimentary **trapezius** muscle.

Observe the position of the lateral line, marking the situation of the horizontal **myoseptum** which separates the dorsalis trunci (**epaxial musculature**) from the rectus

lateralis muscle (the most dorsal part of the **hypaxial musculature**).

> Does the dorsal end of the pectoral girdle provide any attachment for epaxial musculature?
>
> Does M. rectus lateralis extend forwards anterior to the girdle (15), and does it gain any attachment to the girdle? (16)
>
> Is the rudimentary trapezius innervated from the vagus nerve? (17)

Divide the trapezius muscle, and detach the ventral constrictor muscle from the girdle. The dorsal end of the last or **fifth branchial arch** is deeply situated under cover of M. trapezius. Separate this arch from the girdle, *dividing* the connecting **branchioscapular ligament**. The **hypobranchial nerve** is now visible, placed upon the superficial wall of the upper end of the **common cardinal vein** (Duct of Cuvier). Follow this nerve dorsally to its origin from a number of cervical nerves.

> Do these contributions to the hypobranchial nerve pass dorsally or ventrally to the vagus? (18)

Open the common cardinal vein.

> Does the **visceral trunk** of the **vagus** pass medially or laterally to this vein? (19)

Immediately behind the auditory capsule, in the floor of the anterior cardinal sinus, identify the **glossopharyngeal nerve**, as it crosses a **tendon** of origin of rectus lateralis which is attached to the lateral part of the auditory capsule (constituting a rudimentary serratus, cf. p. 99).

Place a knife in the first gill-slit and carry it upwards and downwards so as to open up the first branchial chamber.

Notice the extensive pharyngeal opening, contrasting with the small pharyngeal openings of the branchial pouches of the lamprey.

Identify the large posttrematic and small pretrematic branches of the glossopharyngeal nerve. A small nerve, the **pharyngeal branch of the glossopharyngeal** nerve, leaves the pretrematic branch as they lie on the above-mentioned tendon of sacrospinalis; and it immediately turns round to the under aspect of the tendon. Its further course forwards between the pharyngeal roof and the auditory capsule along with the internal carotid artery will be examined later.

The Hypobranchial Region.

Detach the fore-part of the ventral constrictor from the lower jaw, on one side. Turn it medially. Deep to it is another layer of the ventral constrictor which is attached to the ceratohyal; both layers are continuous behind with the part of the ventral constrictor attached to the branchial arches.

Reflect the whole of this ventral constrictor towards the mid-ventral line and *cut* it through where it is continuous with that of the other side, taking care not to injure the sagittally-placed **coracomandibularis muscle** which is just deep to it in the mid-line.

Observe the relation of the ventral constrictor to the branchial chambers. M. coracomandibularis is attached by a median aponeurosis to the pectoral girdle between the coracoarcuales communes muscles.

Deep to the coracomandibular muscle are the two coraco-hyoid muscles, superficial to the fore-end of which is the **thyreoid gland**.

The coracoarcualis communis passes forwards to be attached by six heads into the lower parts of the hyoid and branchial arches (the heads being distinguished as the coracohyoid and five coracobranchial muscles) with the intervention of strong attachments to the **pericardial wall** and a median raphe.

As the following dissection proceeds the interior of the oropharynx should be examined as opportunity arises. Observe at this stage that just within the mouth the basihyal forms a prominence which is continued backwards as a ridge between the lower ends of the branchial chambers. A depression is found round the fore-end of the basihyal.

> Is there any muscular tongue?
> What do you think is the action of the coracohyoid muscles?

Detach the coracohyoid muscle of one side from the ceratohyal, and identify the common trunk of the two foremost **afferent branchial arteries** (formed from the second and third aortic arches of the embryo). Follow them to the hyoid and first branchial arches respectively. The ventral part of the mandibular aortic arch has disappeared in the course of development, but a derivative of its dorsal end has been already dissected (p. 14).

Divide the first coracobranchial muscle and identify the fore-end of the **ventral aorta**. Identify the ventral anastomoses between the efferent branchial arteries round the lower ends of gill-slits.

Divide the second coracobranchial muscle (pushing the branchial apparatus sideways for a clearer view), and identify the next **afferent branchial artery**, destined for the second branchial arch and developed from the fourth

aortic arch. It is seen lying on the third coracobranchial muscle. Care must be taken not to injure the **hypobranchial artery** which derives blood from the efferent branchial system of arteries, and passes backwards towards the pericardium on the *ventral* aspect of the hinder afferent branchial arteries.

Cut through the third coracobranchial muscle and identify the afferent branchial artery of the third branchial arch; then cut the following coracobranchial muscle and find the next afferent branchial artery, the hindmost of the series, which may arise in common with the preceding.

> Does any branch of the last afferent branchial artery pass to the hinder aspect of the last gill-slit? (20) Is there a hemibranch here?

Pick up the hypobranchial nerve. It passes deep to the last coracobranchial muscle, between it and the **pericardial wall.** Remove the coracoarcualis communis muscle, together with the remains of coracohyoid and coracobranchial muscles, and examine the distribution of the hypobranchial nerve. This nerve is represented in a modified form by the hypoglossal nerve and the ansa hypoglossi of Man.

Re-identify the visceral branch of the vagus. Near the common cardinal vein and close to the **oesophagus**, the vagus breaks up into large branches which pass on to the stomach-wall. Just anterior to this subdivision the vagus gives off a **cardiac branch**. Follow this as far as the pericardium.

Ascertain the mode of connection of the hypobranchial artery with the efferent branchial arteries. Examine its distribution by means of **coronary** and **pericardiac** branches.

Divide the symphysis of the lower jaw. Carry the knife through the mucous membrane of the floor of the mouth, close to the lower jaw, and turn the lower jaw outwards, peeling the mucous membrane from its deep aspect as you do so. The depression in the floor of the mouth around the fore-end of the 'tongue' is provided with blood by a **lingual artery**[1], and it is innervated by the **internal mandibular** nerve which has been seen in a previous dissection. Follow both of these to their distribution.

> Whence does the lingual artery derive its blood? (21)
>
> Compare this condition with that in the frog.

Open up the last gill-slit and observe the **gill-rakers**, and at the entrance to the oesophagus, observe the oesophageal rakers.

Auditory Region.

Re-identify the cut ends of the endolymphatic ducts. Follow the cervical contributions of the cervical nerves to the hypobranchial nerve past the rectus lateralis and dorsalis trunci muscles to the vertebral column.

> Do they pass dorsally or ventrally to the lateral line branch of the vagus.

Follow the lateral line branch of the vagus caudally until it reaches a superficial position, between the dorsalis trunci and rectus lateralis.

Carefully *remove* the thin layer of cartilage from the

[1] Also known as the 'external carotid'. This term is, however, applied in the higher Tetrapoda to a vessel which includes not only a part of the lingual artery of the embryo but also a part of an anastomotic channel between this and the stapedial artery. The term 'external carotid' has also been sometimes inappropriately applied to the orbital branch of the internal carotid artery of Selachii (p. 12).

posteromedial part of the roof of the auditory capsule until you come to the **posterior semicircular canal**. This is nearly parallel to the vagus nerve, just above and anterior to it.

The fore-end of the posterior semicircular canal communicates just behind the ductus endolymphaticus with the **utricle**. Just in front of the ductos endolymphaticus is the hinder end of the **anterior** (superior) **semicircular canal**, also opening into the utricle.

Cut away the roof of the auditory capsule laterally to the ductus endolymphaticus and find the **lateral** (horizontal) **semicircular canal**, medial to the **vena capitis lateralis**, and then expose the utricle. A small ventral diverticulum from the utricle is the **saccule**. Observe that there is no cochlea.

Follow the anterior semicircular canal forwards to its anterior ampullated extremity, just above the hyomandibular nerve.

> What ampullae can you find on the other semicircular canals?

Compare this membranous labyrinth with that of Man.

Follow the vagus nerve forward into the skull. *Remove* the dorsalis trunci (but not the rectus lateralis) as far back as the pectoral girdle.

Remove the cartilage of the cranial roof in its whole length on one side. Notice the strong perichondrium (dura mater) lining the cranial cavity.

> Which parts of the brain come into close relation with the cranial roof? Observe the extensive subdural spaces, and contrast the condition in mammals.

Does the fore-brain reach the anterior end of the cranial cavity?

Examine the olfactory tracts and note the relation of the olfactory bulb to the olfactory sac. Open the **olfactory sac.**

Is the mucous membrane of its walls raised into folds?

Identify the **cerebellum**, **optic lobes**, **medulla**, **fourth ventricle** with **chorioid plexus**, **auricular lobes**[1] projecting laterally below the cerebellum.

Remove as much of the upper part of the auditory capsule as will enable you to see the passage of the vagus and hyomandibular nerves through the cranial wall.

The auditory nerve leaves the brain just behind the facial nerve.

Can you distinguish the origin of the deep ophthalmic nerve from that of other parts of the fifth cranial nerve?

Find the semilunar (Gasserian) ganglion, and the origin from the brain of the glossopharyngeal nerve.

Cut the afferent pseudobranchial artery. *Disarticulate* the hyomandibular cartilage from the articular surface on the auditory capsule, taking care not to injure the mucous membrane of the pharynx. *Cut away* the lateral aspect of the auditory capsule, lateral to the glossopharyngeal foramen. At the dorsal end of the first gill-cleft recognise again the junction of pretrematic and posttrematic arteries. From the vessel formed by their union there arise two

[1] Or 'acoustico-lateral areas'. They have sometimes been described by the misleading name of 'restiform bodies'. The latter name is, however, applied in the higher Tetrapoda to specialised parts of the medulla, which must be distinguished from the acoustico-lateral areas of fish.

vessels, the first efferent branchial artery and the **internal carotid artery**[1] (lateral dorsal aorta). Follow the latter forwards beneath the auditory capsule, along with the **pharyngeal branch of the glossopharyngeal nerve** (a nerve which is comparable with the tympanic branch of the glossopharyngeal nerve in Man).

> On which side of the spiracle do these structures pass?

Cut the hyomandibular nerve. Deep to the auditory capsule, and opposite the hyomandibular foramen, the internal carotid gives off the orbital artery, and then itself turns sharply medially between the mucous membrane and under surface of the neurocranium. The **orbital** artery will be seen to have a very short course through the base of the auditory capsule, close to the **palatine** branch of the facial nerve.

Cut the superficial ophthalmic nerve, and *remove* the side-wall of the cranium where it forms the medial wall of the orbit, down to the level of the trochlear nerve, which should then be lifted from its foramen. Then remove a further section of the wall down to the level of the oculomotor and optic foramina.

Identify the efferent pseudobranchial artery in its passage through the cranial wall, to reach the side of the mid-brain just above and behind the optic foramen.

> Does this artery pass above or below the oculomotor nerve? How is it distributed on the brain?

[1] This has also been sometimes called 'common carotid', but the name is unsuitable owing to the use of this name for another vessel in Man and other mammals, and to its varied mode of employment in fish. The term 'hyoid efferent' is also an inappropriate name for this artery in fish.

Examine the origins from the brain of the optic, oculomotor and trochlear nerves.

Cut the origins of the trochlear, trigeminal, facial and auditory nerves from the brain, *remove* what is left of the auditory capsule and identify the **hypothalamus** and **saccus vasculosus**. By *removing* a part of the cranial floor the foramen by which the internal carotid artery enters the cranium can be reached and the anastomosis of this artery with the posterior branch of the efferent pseudobranchial artery can be seen.

Remove the chorioid plexus from the fourth ventricle. In the floor of this ventricle you will see a pair of ridges close to the mid-line. These are the right and left **somatic motor areas**. Laterally to them, and still within the fourth ventricle, there is a narrow depressed area on each side; these are the **visceromotor areas**. The prominent white structures, with notched medial margins at each side of the fourth ventricle, are the **viscerosensory areas**; more laterally still are smooth white prominences, the **somatic sensory areas**. Notice that the auricular lobes, or acoustico-lateral areas, appear to be an antero-lateral continuation of the somatic sensory areas.

The Pectoral Fin and Girdle Region.

Remove the skin from the body-wall and back for some distance behind the pectoral girdle, if this has not already been done. Separate the epaxial dorsalis trunci muscle from the hypaxial abdominal musculature, and again notice the horizontal myoseptum separating them along the course of the lateral line. The hypaxial abdominal musculature consists of a **lateral rectus muscle**, just below the myo-

septum, and of a **M. obliquus abdominis** which occupies the body-wall superficial to the peritoneal cavity.

M. obliquus abdominis has an anterior attachment along the hinder margin of the pectoral girdle, as far as the mid-ventral line.

Contrast the immobility of this pectoral girdle, with its mobility in a frog or rabbit.

> What functions would you attribute to this girdle beyond that of providing an articulation for the fin and a site of attachment for its muscles?

Detach the sacrospinalis and rectus lateralis muscles from the dorsal part of the pectoral girdle; deep to them will be found the brachial plexus and subclavian artery in the dorsal wall of the postcardinal sinus close to its junction with the common cardinal vein. Observe that there is no serratus muscle nor are there any ribs on the deep aspect of the girdle.

Open up the space between the body-wall and fin, the **axilla**.

Observe the appendicular nerves dividing into smaller **dorsal** and larger **ventral** divisions on reaching the fin-margin. All these nerves are distinguished as **metazonal** since they pass caudally to the pectoral girdle. Running along the postaxial margin of the fin (the margin which is adjacent to the axilla) will be seen the **brachial artery**, one of the terminal branches of the subclavian artery.

On the surface of the fin, which is turned upward or medially according to the position of the fin, will be seen **M. levator** which is supplied by dorsal branches of appendicular nerves. It has an adductor as well as a levator action. Anterior to its origin from the girdle will be seen the extreme supero-dorsal part of the origin of the ventral

M. depressor, this part of the muscle possessing a marked abductor action on the fin. The hinder and more ventral part of the muscle, which forms the lateral wall of the axilla, has a definite depressor action. A differentiation of the ventral fin musculature which has proceeded much further in Tetrapoda is seen here in a rudimentary condition (cf. p. 53).

Re-identify the hypobranchial nerve. The hindmost spinal nerve which contributes to it also sends a contribution to the brachial plexus, and takes part in the formation of a **supracoracoid nerve** which pierces the girdle.

In view of its course relative to the girdle this nerve is described as being **diazonal** in its course.

> How many other spinal nerves contribute to form the supracoracoid nerve? (22)

Detach M. levator from the girdle, and reflect it towards the fin.

Cut off the part of the pectoral girdle which is above the articulation of the fin; and detach the fore-part of the ventral or depressor muscle from the girdle.

Follow the subclavian artery to the supracoracoid foramen. Here it divides into three arteries almost at the same point, the **brachial** which has already been seen, the **supracoracoid**[1] which passes to the ventral aspect of the fin through the supracoracoid foramen with the nerve of that name, and the **coracoid artery**, which passes ventrally between the pectoral girdle and the **peritoneal cavity**.

[1] The term 'brachial artery' which has been sometimes applied (*e.g.* by J. F. Daniel) to this vessel is unfortunate, since the vessel in Tetrapoda for which this is a well-recognised name passes caudally to the girdle with the metazonal nerves and follows the postaxial margin of the limb in its more proximal part. The supracoracoid artery is found in Tetrapoda accompanying the diazonal supracoracoid nerve.

In order to follow the last-named artery it will be necessary to *pare away* some of the anterior margin of the girdle. Near the mid-ventral line it turns sharply in a caudal direction and runs—as the **ventral abdominal artery**—between the oblique abdominal muscle and the peritoneum (it is comparable with the internal mammary artery of Man).

Make an incision through the fin in a proximo-distal direction, and ascertain whether any of the fin musculature is attached to the dermal fin-rays (23).

> Did you see any similar fin-rays in the median fins of the lamprey? (24)

Examine the articular surface between the fin and girdle.

> Is the girdle provided with a concave glenoid facet similar to that of Tetrapoda?

Pericardium and Heart.

Make a small incision through the peritoneum just deep to the coracoid artery. Observe that the **septum transversum** which separates the peritoneal cavity from the pericardium is thin and non-muscular.

Open the pericardium (to obtain a clear view of it the more superficial part of the branchial apparatus is advantageously cut away).

Identify the **ventricle**, **conus arteriosus** (what valves do you find inside the conus?), **atrium** (auricle), and **sinus venosus**. Pass a seeker dorsally to the heart, between the **arterial** and **venous mesocardia**. This passage is the **transverse sinus**.

> Is the oesophagus just dorsal to it, as in Man?

Pass a seeker down the common cardinal vein into the sinus venosus. Dorsally to the sinus venosus there is a passage leading caudally from the transverse sinus. Pass a seeker along this. It is the **pericardioperitoneal canal.**

Peritoneal Cavity.

Re-identify the lateral line which marks the position of the horizontal myoseptum separating Mm. dorsalis trunci and rectus lateralis. Notice the sinuous course of the **myocommata** from the mid-dorsal to the mid-ventral line.

Arising from the fascia covering the oblique abdominal muscle just above the **pelvic fin** will be seen the **levator muscle** of that fin. *Detach* it and examine the distribution of the branches of spinal nerves reaching the fin.

> Do they divide into dorsal and ventral branches for the respective aspects of the fin as do those of the pectoral fin?
>
> Do any of the nerves for the pelvic fin pass through the girdle? (25)
>
> Does the pelvic fin of the male differ from that of the female?

Remove a part of the oblique abdominal muscle so as to expose the **iliac artery** which passes round the lateral aspect of the peritoneal cavity to reach the fin and anastomose with the ventral abdominal artery.

Make an incision through the hypaxial musculature at the junction of the rectus lateralis and oblique abdominal muscle, and then through the peritoneum, along the whole length of the peritoneal cavity.

Observe that at the hinder end of the peritoneal cavity there is no peritoneal pouch, ventral to the rectum, like the recto-vesical pouch of mammals.

There is a tubular prolongation of the peritoneal cavity backwards on each side of the rectum and cloaca.

Do these lead to the **abdominal pores**?

Cut the fore-end of the oblique abdominal muscle away from the pectoral girdle, and inspect the deep aspect of the ventral abdominal wall. Identify the ventral abdominal arteries, and, more laterally, the **lateral abdominal veins.** Follow one of these forwards and backwards, and ascertain the connections with other veins.

Identify the **lateral lobes** of the **liver**, and the smaller **central lobe** in which the **gall-bladder** is partly embedded.

Is there any falciform ligament (ventral hepatic mesentery) as there is in Man?

In the demonstration specimen of the embryo, ascertain the site of connection between the yolk sac and the alimentary canal.

Identify the **stomach**, **pylorus**, **duodenum**, **colon**, **rectum**, **pancreas** with a **body** and a **left lobe**, and the **ovary** (or **testis**). In a female find the **Müllerian duct.**

Has the ovary (or testis) a mesentery? Examine the mesorchium for **vasa efferentia** passing from the testis to kidney.

Has the Müllerian duct a mesentery? Does it contain any embryos (this animal is viviparous)?

If there are embryos the high degree of vascularity of the mucous membrane of this part of the duct will be evident.

Find the **rectal gland**; the **posterior colic artery** reaches the gut by way of its mesentery.

Has the stomach a complete **dorsal mesogastrium**? (26)

How does the course of the **coeliac artery** differ from that of the coeliac axis of Man (or the rabbit)?

Is the **spleen** situated in the dorsal mesogastrium as in Man? Is this also the situation in the frog and rabbit? (27)

Observe that the left lobe of the pancreas has a mesentery which joins the **mesocolon**. The mesocolon is complete as far back as the **anterior colic artery** (sometimes termed 'anterior mesenteric'). Part of the mesocolon is fused to the dorsal mesogastrium, limiting a **gastrocolic pouch**, in which lies the left lobe of the pancreas.

Compare the distribution of the coeliac and anterior colic arteries with those of the coeliac axis and superior mesenteric artery of Man.

Can you find any omental bursa (lesser sac)? The band-like mesentery in which the **hepatic portal vein** and **bile-duct** pass from the duodenum to the liver is a remnant of the gastrohepatic (lesser) omentum, representing its free margin. The space between this and the coeliac artery corresponds approximately to the epiploic foramen of higher Tetrapoda.

Find the common opening of the Müllerian ducts, on the ventral aspect of the fore-end of the liver.

Remove the right **ovary** (or testis), and the fore-part of the Müllerian duct in a female. Cut the short **dorsal mesentery** of the right lateral lobe of the liver, and notice

that there is no extensive 'bare area' of the liver directly adherent to the septum transversum.

Dissect the portal vein and ascertain its tributaries. Follow the **bile-duct** (**ductus choledochus**) to its opening into the alimentary canal. The pancreatic duct enters the gut separately, at the termination of the duodenum.

Follow the branches of the vagus on to the wall of the stomach, and find again the cardiac branch of the vagus.

Carry the knife backwards from the angle of the mouth through the middle of the branchial apparatus to the oesophagus and stomach. Notice again the oesophageal rakers, and the shortness of the oesophagus. It is provided with a thick muscular wall.

What are the relations of the oesophagus?

If the opposite side of the fish has already been dissected, the gut may now be *removed* by cutting through the hinder end of the colon and the fore-end of the stomach.

Examine under water the interior of the part of the alimentary canal so removed, washing out its contents.

What functional significance do you attribute to the spiral valve of the colon?

Cut through the side-wall of the rectum as far as the cloaca. Its opening is anterior to the prominent **urinary papilla** (in females), the urogenital papilla (of males).

In females observe the position of the openings of the Müllerian ducts.

Compare the positions of these openings into the cloaca with those which are seen in the cloaca of the frog.

Identify the kidneys (opisthonephroi), and in males, the ductus (vas) deferens running from the base of the mesorchium along the ventral surface of the kidney.

Cut off the tip of the urogenital (or urinary) papilla. Follow up its small canal to the urogenital (or urinary) sinus. In the males the urogenital sinus receives the openings on each side of a ductus deferens and an opisthonephric duct, and of a ventrally-placed **sperm-sac.**

> Does any part of either the pectoral or the pelvic girdle lie immediately next to the peritoneum?

Detach the ventral or **depressor** muscle of the pelvic fin from the girdle, and examine the articulation of the fin with the girdle.

> Has the latter a concave acetabular surface as in Tetrapoda? (28)

A large **diazonal** nerve will be found passing through the girdle immediately anterior to the articulation.

Examine the hypaxial musculature behind the level of the peritoneal cavity. The distinction between M. rectus lateralis and M. obliquus abdominis disappears behind this level.

The **postcardinal sinus.** Find its opening into the common cardinal vein, and cut it open as it passes backwards on the dorsal wall of the peritoneal cavity. The origin of **segmental** arteries from the dorsal aorta will be seen.

> Does the sinus pass medially or laterally to the kidney? What is its relation to the dorsal aorta?

Follow one of the segmental arteries into the body-wall. Those which are opposite the kidney provide branches for that organ. The more anterior segmental arteries provide similar branches for the Müllerian duct, which will shew a local enlargement if the animal is pregnant.

Each segmental artery also provides a dorsal branch passing dorsally beside the vertebral column. This dorsal branch provides a spinal branch which enters the column to supply the spinal cord, and a small intercostal branch.

Examine the surface of the section already made in the tail region.

Identify the caudal artery, **caudal vein** and **haemal arch** of a vertebra. Open up the caudal vein in a cranial direction. It divides at the hinder end of the kidneys into right and left **renal portal veins**, which pass forwards and terminate in the veins of the kidneys.

> Do they pass to the lateral or medial side of the kidneys? (29)

Make a tranverse incision through the rectus lateralis and dorsalis trunci some distance behind the *pectoral* girdle.

> Are the ribs embedded in the horizontal myoseptum or in some other fascial plane? (30)

Re-examine the pericardioperitoneal canal. This will be found opening on the ventral aspect of the oesophagus, on the dorsal wall of the gastrohepatic recess.

Remove the mucous membrane from the dorsal wall of the pharynx and oesophagus.

> Is there any musculature in the dorsal wall of the pharynx, anterior to the oesophageal sphincter?

Examine more fully than was previously possible the connections of the efferent branchial arteries with the dorsal aorta, the origin of the subclavian arteries, and the course of the internal carotid artery and of its branch the orbital artery.

Find the **ventral vertebral artery** which arises on each

side from the foremost efferent branchial artery, and, passing forwards, joins the internal carotid artery.

How does its course differ from that of the vertebral artery of the rabbit or Man?

It will be observed that a small **circulus cephalicus** is formed by the foremost efferent branchial arteries and the internal carotid arteries, an arterial circle closed both cranially and caudally by the union of right and left arteries. In bony fish and Tetrapoda the hinder limit of the arterial circle is placed much more caudally.

Does the notochord extend into the skull?

Subphylum: CRANIOTA.

Branch: GNATHOSTOMATA.

Grade: *TETRAPODA*.

Class: AMPHIBIA.

Subclass: URODELA.

Family: PROTEIDAE.

Genus and Species: *Necturus maculatus* (or *Menobranchus lateralis*).

Necturus, the Mud-puppy.

The Urodela have adhered to the general form of body of the early Amphibia more closely than the other modern Amphibia, viz. the Salientia (Anura) and the Apoda (Gymnophiona or coecilians). The Salientia, comprising the frogs and toads, having undergone a high degree of specialisation of the hind-limbs in relation to their saltatorial habits, along with a reduction of the tail. The Apoda, on the other hand, have become limbless, and no trace remains of the limb-girdles.

All these modern Amphibia differ considerably from the fossil amphibian Group of Stegocephalia, which has been extinct since the earlier part of the Mesozoic period. The earliest Stegocephalia, whose remains have been found in rocks dating from as early as the Carboniferous period, were somewhat fish-like in general form, but they were provided with limbs of the tetrapod pattern instead of paired fins. In internal structure they shewed much affinity with certain contemporary bony fish. The system of bony plates formed in the deeper layers of the skin of these fish, which provided a complete bony covering to the dorsal aspect of the head, was retained throughout the history of the Stego-

cephalia, but it has undergone reduction and modification in the modern amphibians and reptiles (which were evolved from the Stegocephalia). The skull and vertebral column have undergone considerable divergent structural modifications in the various modern amphibians and reptiles. Internal gills have also disappeared. The adaptations to a terrestrial life are, on the other hand, far less complete in the modern Amphibia than in reptiles. The earlier stages in the life-history of all modern amphibians are passed in the water. A few fossil Urodela, resembling modern ones belonging to the families which comprise *Cryptobranchus*, *Amblystoma* and the salamanders, have been found in Mesozoic and Tertiary rocks, but they scarcely assist in determining the course of evolution of the Subclass from the Stegocephalia. *Hylaeobatrachus*, of the end of the Jurassic, was indeed already a characteristic urodele of the modern kind.

The nearest relatives of *Necturus* now living comprise only two genera of small animals living in subterranean waters, the one in Dalmatia, the other in Texas. In both of these the eyes have become almost or quite functionless, and in the Dalmatian animal (*Proteus*) the limbs have become greatly reduced and swimming is effected by trunk movements. These animals, constituting with *Necturus* the Family of Proteidae, retain throughout life the external gills and branchial clefts which are a feature of the larval forms of Urodela generally. The larvae of *Necturus* are marked by stripes which disappear in the adult form.

Necturus presents a number of features related to the secondary acquisition of fully aquatic habits throughout life, besides the retention of external gills, viz. modifica-

tions of the limbs, a powerful trunk musculature and a dorso-ventral expansion of the tail by a fin which is not supported by radials.

There are two species of the Genus *Necturus*. They are found in the eastern parts of the United States of America. In addition to the urodele *Necturus* which is dissected, demonstration specimens of other urodeles (*Amblystoma* and *Cryptobranchus*) will be exhibited. Serial microscopic cross-sections of *Amblystoma* will also be employed for the more accurate study of various relations, especially in the head and shoulder region.

External Examination.

Notice the external nares on the end of the snout. Short nasal passages lead from these to the **internal nares** opening into the mouth just within the marginal row of teeth. In a Spalteholz preparation observe the olfactory sac on each side, opening into this passage.

> How many digits do you find on each limb?
>
> Which aspects of the limbs are applied to the body-wall, when the limbs are in a retracted position? (1) Contrast these limb-postures with those of the retracted fins of fish.
>
> Are there any scales in the skin?

In demonstration specimens of *Cryptobranchus* (belonging to another family of Urodela), notice the more extensive adaptation of the limbs to an aquatic life in the marginal skin flaps and webbing of the fingers and toes.

In the cleaned specimens of skulls notice that there is no hard palate, the internal nares being situated just behind

the **premaxillae**, and far apart as in primitive Amphibia generally; cf. chart of skull of *Loxomma* (*Orthosaurus*).

Are there any teeth in the roof of the mouth, apart from the marginal series?

Is there any conjunctival sac? (2)

Can you find an external auditory meatus, or tympanic membrane? (3)

How many **branchial apertures** can you find? (4)

How many **external gills** do you find on each side?

Identify the **cloaca**. Notice the form of the tail.

Dissection.

Reflection of skin from the head. All incisions must be restricted to the skin. Confine your dissection to the *left* side of the animal unless this side has already been dissected.

Incisions:

1. In the mid-ventral line, forwards from the level of the pectoral girdle.

2. From the fore-end of Inc. 1, backwards below the lower lip, to the angle of the mouth.

3. From the hinder end of Inc. 2, forwards above the upper lip.

4. From the hinder end of Inc. 1, dorsally just in front of the foremost external gill, to the mid-dorsal line.

Reflect the area of skin thus marked out, commencing ventrally and taking care not to reflect the thin subjacent muscle-sheet, the **sphincter colli**. On the side of the head the skin will be found to extend across the eyeball.

Identify the **external jugular vein**, which passes dorso-caudally from the angle of the mouth. Above this vein, and behind the eye, there is a large jaw-muscle, the **ad-**

ductor mandibulae posterior[1]. Between this muscle and the mid-dorsal line will be found another jaw-muscle, the **pseudotemporalis**, which will be found at a later stage of the dissection to reach the jaw between the adductor mandibulae posterior and the eye. In the angle between these muscles, posteriorly, will be found the fore-end of **M. sacrospinalis (dorsalis trunci)**. In front of the eye will be seen the elongated **nasal sac**.

Find the **superficial ophthalmic nerve**, a branch of the facial nerve, which emerges from the interval between the adductor mandibulae posterior and the pseudotemporalis about one-third of an inch from the eye.

The floor of the mouth is supported by a part of the sphincter colli comparable with the ventral constrictor of fish; this part is attached on each side to the lower jaw and is distinguished as the **mylohyoid muscle**. Further back the sphincter is attached on each side to the **ceratohyal**, while behind the angle of the mouth it extends dorsally (cf. the dorsal constrictor of fish) to gain attachment to the fascia covering the large **M. ceratohyoideus externus**. Behind this muscle and just in front of the foremost external gill it also gains attachment to the first branchial arch. Examine these attachments. The more dorsal part of the external ceratohyoid muscle is exposed above the sphincter, between the adductor mandibulae posterior and the foremost gill.

Find the **external mental branch**[2] of the facial nerve,

[1] Lakjer's name (1926). It has often been known by the name of 'masseter'; but this name is better avoided in view of the long-established employment of the name in a different sense in mammals.

[2] Coghill's names (in *Amblystoma*), 1902. These nerves represent the external mandibular nerve of the dogfish, supplying lateral line (neuromast) organs.

running forwards with the **external jugular vein** immediately behind the angle of the mouth. The **internal mental branch**[1] of the same nerve runs forwards superficially to the mylohyoid, just medially to the lower jaw.

Remove a part of the external jugular vein, and follow both these nerves into the intermuscular cleft behind the adductor mandibulae posterior, where they will be found to join. The internal mental branch crosses the **depressor mandibulae muscle**, close behind its insertion on the hinder end of the lower jaw.

Cut through the mylohyoid in the middle line, and turn it laterally. The external ceratohyoid muscle is thus fully exposed, also the ceratohyal cartilage into which it is inserted. In front of and lateral to this cartilage the mucous membrane of the mouth is exposed, while close to the mid-line will be seen an elongated muscle corresponding to the **coracomandibular muscle** of the dogfish. This is attached behind to the fascia covering the **rectus muscle**. It is probably represented in the higher tetrapods by the **geniohyoid**.

Just deep to the skin, and immediately below the eye, find the **buccal branch** of the facial nerve (destined for lateral-line organs). A small nerve, the **maxillary**, leaves it just below the eye and enters the upper lip. Their common trunk has been named the 'infra-orbital trunk'. Follow this common trunk dorso-caudally into the interval between the adductor mandibulae posterior and pseudotemporalis.

Detach the hinder end of the former muscle from the cranium, and turn it forwards, taking care not to injure adjacent nerves. Beneath it the **mandibular nerve** passes

[1] See note 2, page 44.

towards the angle of the mouth and then on into the region of the lower jaw. It supplies the mylohyoid, the adductor mandibulae posterior and the pseudotemporalis.

Define the anterior margin of the pseudotemporalis muscle. *Reflect* it from its cranial attachment, and *cut* it off close to its insertion, taking care not to injure the superficial ophthalmic and buccal nerves. Running forwards on its deep aspect, near the mid-line of the head, will be found the **deep ophthalmic nerve**. When just behind the level of the eye the **optic nerve** passes obliquely forwards and laterally below the N. ophthalmicus profundus. Notice that the latter nerve emerges from the skull by a separate foramen nearly midway between the optic foramen and that by which the buccal, mandibular and superficial ophthalmic nerves leave the cranium.

Ascertain that the adductor mandibulae posterior and pseudotemporalis muscles are inserted close together, partly on the coronoid process of the mandible.

> How do their dorsal attachments differ from those of the adductor mandibulae of the dogfish (which represents the same muscle-mass)? The bony fish are in this respect more like the Urodela.
>
> With what difference in the jaw-mechanism do you think this difference of muscle-attachments is related?

Cut through the strong fascia covering the upper part of the external ceratohyoid muscle, and reflect it dorsally to its attachment to the cranium. Two small muscles will be found between the external ceratohyoid muscle and the cranium, extending downwards and forwards to gain an

attachment to the extreme hinder end of the lower jaw. They are together known as the **depressor mandibulae.**

> Is the function of depression of the lower jaw carried out by a similar muscle or by some other muscular arrangement in the dogfish? (5)

Examine the interval between the hinder ends of the external ceratohyoid muscle and of the more lateral belly of depressor mandibulae. A relatively large branch of the **glossopharyngeal nerve** crosses both these muscles to reach the base of the first external gill. Follow this nerve towards the cranium. It disappears into the interval between the two bellies of the depressor mandibulae muscle.

Open up the interval between these bellies. A small muscle, the **levator muscle** of the first branchial arch, will be seen passing ventro-caudally from the hinder end of the skull to the first branchial arch. The branch of the glossopharyngeal nerve passes to the lateral side of the levator muscle. The bellies of the depressor mandibulae take origin respectively from the auditory capsule and from the dorsal end of the first branchial arch.

Cut through the lateral belly just anterior to the site of crossing of the branch of the glossopharyngeal nerve. The main posttrematic branch of the glossopharyngeal nerve will be seen passing deep to it, lying against the mucous membrane of the pharynx. It then passes deep to M. ceratohyoideus externus.

Reflect the latter from behind forwards, and follow this branch of the glossopharyngeal between the muscle and the first branchial arch.

As the external ceratohyoid muscle is turned forwards

a considerable area of the mucous membrane of the pharynx is laid bare. Anteriorly this muscle is attached to the ventral portion of the hyoid arch.

What is the action of this muscle?

The **lingual artery** passes superficially to the ventral end of the first branchial arch, overlapped by the external ceratohyoid and coracomandibular muscles.

Incisions. Make a skin incision extending caudally in the mid-dorsal line to a point opposite the fore-limb. From the hinder end of this incision make a vertical one down the side of the body as far as the shoulder.

Reflect the area of skin marked out from the mid-line to the bases of the external gills, taking care not to reflect the subjacent **levator branchiarum muscle** with the skin, nor, in the hinder part of this area, the superior margin of the scapula. The levator branchiarum takes origin from the fascia covering sacrospinalis. Two large **branchial branches** of the vagus should now be identified, passing through the levator branchiarum into the external gills.

Reflect the levator branchiarum laterally. Deep down in the interval between the external gills and sacrospinalis the **vagus nerve** runs backwards, giving off a **lateral line branch** opposite the first gill. This branch passes backwards on the lateral aspect of the sacrospinalis.

Remove the skin on the ventral aspect of the body, in front of the fore-limb and ventral to the gills.

The **trapezius muscle** takes origin in line with the levator branchiarum; it appears indeed to be merely the more posterior part of that muscle. It will, however, be found to gain attachment ventrally on the shoulder-girdle, on the anterior margin, opposite the shoulder-joint. Find its nerve-supply.

The **hypoglossal nerve** (which is comparable with the hypobranchial nerve of the dogfish and, like that nerve, formed by contributions from the anterior spinal nerves) runs ventrally on the deep aspect of the trapezius. It crosses superficially to the vagus just behind the last gill, and then runs forwards on the ventral aspect of the branchial apparatus. The **pulmonary artery** runs backwards with the vagus nerve.

Compare the course and relations of the hypoglossal nerve with those of the hypobranchial nerve of the dogfish.

The **aortic root**[1] is a large vessel situated ventrally to the vagus, opposite the second gill. It receives blood from the second and third gills. It is united by a small cross-connection, the **ductus caroticus**, with the **internal carotid artery**, which runs forwards to the head from the first gill, deep to the **levator muscle** of the **first branchial arch**. *Reflect* the levator and ascertain that the internal carotid artery passes deep to the glossopharyngeal nerve.

> Whence does the pulmonary artery derive its blood?

Extending forward on the ventral aspect of the pharynx and branchial apparatus there is a large muscle-mass consisting of a forward continuation of the ventral musculature of the trunk (**Mm. rectus** and **obliquus internus**). Superficial to its lateral part, in front of the pectoral girdle, there is a **sternohyoid muscle**[2]. The hypoglossal nerve runs forward between this muscle-mass and the branchial apparatus. Its relation to the pericardium will be seen later.

[1] Also called 'systemic arch' or 'arch of the aorta'.

[2] Though not attached to a sternum in *Necturus*, the corresponding muscle of many amphibians is so attached.

By *removing* small muscles on the ventral aspect of the branchial apparatus the ventral parts of the aortic arches are brought into view. The fourth and sixth of the embryonic series spring from a common stem of some length which divides at the base of the gills; the third aortic arch is more anterior, and runs along the first branchial arch. The hypoglossal nerve runs ventrally to these aortic arches in the floor of the pharynx.

Find the origin of the lingual artery (6).

Shoulder and Forelimb.

Remove the skin from the fore-limb and adjacent part of the trunk. Behind the scapula care must be taken not to reflect **M. latissimus dorsi** with the skin, while similar care must be taken in regard to **M. pectoralis** on the ventral body-wall behind the girdle.

The pectoral girdle has a considerable forward extension, the **procoracoid process**. The **procoracohumeralis muscle** is attached to its superficial aspect, and is employed in advancing the limb. Its nerve-supply (which will be seen later) indicates that it was differentiated from an anterior extension of the **levator-adductor (dorsal) muscle** of the fish-fin.

The left half of the pectoral girdle overlaps the right half in the mid-ventral line. From the surfaces of the overlapping portions there arises on each side a **supracoracoid muscle**. Its hinder margin is overlapped by the pectoral muscle.

Gently *lift* the dorsal end of the scapula away from the body-wall; and contrast the freedom of movement of this pectoral girdle with that of the dogfish. Small muscles pass

fore and aft from its dorsal cartilaginous end, and its deep surface is attached to the body-wall by a **serratus muscle.** The **subclavian artery** and **brachial plexus** are visible in front of the serratus.

Most of the nerves derived from the plexus are **meta-zonal** in position. One nerve, situated more cranially than the others, is **diazonal.** It passes round the side of the ventral trunk musculature deep to the girdle and is joined by a branch from the hypoglossal nerve. The combined trunk passes through a **supracoracoid foramen** in the ventral part of the girdle as the **supracoracoid nerve** (cf. microscopic sections).

On the superficial aspect of the scapula will be seen the **dorsalis scapulae muscle** (cf. p. 66). This and the latissimus dorsi and procoracohumeralis muscles have probably been formed by subdivision of the dorsal levator muscle of the appendage, which was doubtless attached in the early Amphibia to the large subcutaneous bones (cleithrum[1] and clavicle) on the anterior margin of the girdle.

A large **cephalic vein** passes along the **preaxial** side of the limb, and then across the girdle to join the internal jugular vein.

The margin of **M. anconaeus** should be defined just dorsal to the cephalic vein in the arm. The **radial nerve** lies in the groove between this muscle and **M. brachialis inferior**, deep to the vein.

Reflect M. dorsalis scapulae downwards, and find its nerve; this reaches it from behind the girdle and above the arm. Close to its humeral attachment the **circumflex scapulae artery** and **axillary nerve** pass forwards dor-

[1] A mere vestige of this bone is retained in the frog, on the anterior margin of the dorsal part of the girdle.

sally to the shoulder-joint to reach the procoracohumeralis muscle.

Reflect the supracoracoid muscle towards the humerus, and find its nerve-supply from the supracoracoid nerve.

> What do you think are the respective actions of latissimus dorsi and pectoralis?

Fore-limb. *Reflect* M. pectoralis towards the humerus, and cut the subclavian artery and limb-nerves near the shoulder-joint. The girdle and attached limb can now be turned forwards from the surface of the rectus. It will be seen that the sternohyoid muscle still connects the girdle to the head, extending forwards on the deep aspect of the procoracoid process. This muscle joins the rectus muscle and thus gains an attachment on the first branchial arch.

Cut through the sternohyoid and *remove* the limb and girdle from the trunk.

On the medial aspect of the arm find the interval between the anconaeus dorsally and the **coracobrachialis**. The latter takes origin on the girdle between the supracoracoid and the scapular head of anconaeus. Deeply situated in the proximal part of this interval will be found the **long inferior brachial nerve**, the main ventral nerve of the limb, accompanied by the **brachial artery**. They both enter the limb by passing between the **scapular** and **coracoid heads** of **anconaeus**.

> Has the anconaeus a humeral head of origin like the triceps of mammals?

The long inferior brachial nerve corresponds approximately to the musculocutaneous, median and ulnar nerves of Man. It passes between two distinct parts of the coracobrachialis.

The inferior brachial muscle intervenes between the coracobrachialis and anconaeus, and corresponds in part to the brachialis and biceps brachii of man. This muscle, and the coracobrachialis, supracoracoid and pectoralis muscles together represent the **depressor-abductor muscle** of the fish-fin (cf. p. 31).

> To which epicondyle of the humerus are the dorsal forearm muscles (extensors) attached? (7)
>
> Does the radial nerve pass ventrally or dorsally to this epicondyle before it enters the extensor aspect of the forearm? (8)
>
> Does the long inferior brachial nerve enter the flexor (ventral) aspect of the forearm by passing on the ventral or on the dorsal aspect of the **medial epicondyle**? (9)

Pericardiac Region.

The trunk muscles behind the pectoral girdle consist mainly of (1) the sacrospinalis, (2) the rectus, (3) the obliquus externus, and (4) the obliquus internus. The rectus of each side extends forwards from the pelvic girdle, over the dorsal aspect of the pectoral girdle to the branchial skeleton. M. obliquus externus diverges from the rectus just behind the brachial plexus, and, passing dorsally to the latter, is attached to the vertebral column between the spinal nerves and lateral-line branch of the vagus. *Turn* back the fore-end of the external oblique muscle, and identify the **internal oblique muscle** deep to it, extending forwards ventrally to the plexus to join the fore-end of the rectus. The parts of the rectus and internal oblique anterior to the girdle represent a part of the hypobranchial

musculature of the dogfish, and the infrahyoid musculature of Man. The sternohyoid muscle, already dissected, belongs to the same musculature.

Cut through the internal oblique and rectus just behind the level of the girdle, and reflect them forwards to their insertion.

Where are they attached?

Observe that they are firmly connected by their **myocommata** to the lateral wall of the **pericardium**. Remove the hypobranchial parts of these muscles.

Is the relation of the hypoglossal nerve to the pericardium similar to that in the dogfish?

Open the pericardial cavity as far as its anterior end. The **ventral aorta** divides just within the pericardium into two right and two left vessels, viz. the third aortic arch and the common stem of the fourth and sixth aortic arches (of the embryonic series) on each side. These are the only aortic arches retained in the adult *Necturus*.

Follow the pulmonary artery and vein from the lung towards the pericardium. They both pass medially to the **common cardinal vein (ductus cuvieri)**. Caudally to this vein will be found the fore-end of the pleuroperitoneal cavity.

Pass a seeker backwards from the pharynx into the **oesophagus**.

Cut through the mucous membrane between the hyoid and first branchial arches, and then through each branchial arch close above the external gills.

The **pharynx** is a very wide, shallow space (similar in form to that of the embryos in higher tetrapods), with two branchial apertures on each side at its widest part. On its

dorsal aspect the junction of the **aortic roots** to form the **dorsal aorta** can be seen through the mucous membrane. At the level of this junction the alimentary canal suddenly narrows to form the oesophagus; this is provided with a strong muscular wall, and its mucous membrane is thrown into longitudinal folds. The origins of the subclavian arteries from the dorsal aorta will be found just behind the junction of the aortic roots. In the mid-ventral line of the pharynx, just in front of the oesophagus, there is a very small opening, the **aperture of the larynx**. Notice the close relation of the pulmonary artery to the oesophagus.

Is there a muscular tongue as in the frog?

Pericardium and heart. Identify the **atrial part** of the heart, the **ventricle**, **sinus venosus**, and the **bulbus cordis** (truncus arteriosus) which is continued forwards as a ventral aorta. The ventral aorta divides into right and left branches just within the pericardium.

Is there a **transverse sinus**? (10)

Is the bulbus cordis ventral to the atrial part of the heart?

Divide the bulbus cordis close to the ventricle. Open the atrial part of the heart and recognise its subdivision into two atria (auricles).

Is the ventricle also divided into two compartments?

Identify the common cardinal veins (ducts of Cuvier, or anterior venae cavae), and the **posterior vena cava**.

Abdomen.

Remove the skin, on *one* side, from the trunk as far back as the level of the cloaca.

Make incisions (1) along the dorsal margin of the external oblique muscle, and (2) along the mid-ventral line, dividing all structures down to but not including the peritoneum. Peel the rectus and oblique muscles away from the peritoneum as far caudally as a transverse plane one inch anterior to the cloaca. Then cut them across and remove the muscle-mass.

Make two incisions through the peritoneum immediately to the right and left of the mid-ventral line.

Examine the mesenteries.

The liver is connected to the ventral body-wall in the mid-line by a **falciform ligament**. Turn the liver towards the right side. A short **gastrohepatic (lesser) omentum** connects the fore-part of the stomach with the liver. The stomach is connected to the dorsal abdominal wall by a **dorsal mesogastrium**, which is also restricted in its gastric attachment to the fore-part of the stomach.

The **left lung** is the elongated sac-like structure which is attached to the left side of the dorsal mesogastrium. Between the lung and stomach, in the same mesentery, will be found the **spleen**.

> Is the relation of the spleen to the mesenteries similar in the dogfish and in *Necturus*?

The **intestine** is suspended by a **dorsal mesentery**, in which will be seen numerous **mesenteric arteries** destined for the gut-wall. Proximally this is continuous with the **dorsal mesohepar**[1], by which the liver is suspended to the dorsal abdominal wall.

The right lung is attached to the right side of the dorsal

[1] This mesentery contains the posterior vena cava, and is comparable with that which is described as the **caval mesentery** in mammalian embryos.

mesohepar. The **omental bursa** is that part of the peritoneal cavity which is situated between the mesohepar and the dorsal mesogastrium. It communicates with the general pleuro-peritoneal cavity both ventrally and dorsally to the hinder part of the stomach through wide deficiencies that form in the dorsal mesogastrium and lesser omentum in the course of development. At the junction of the mesohepar and mesentery of the intestine the **posterior vena cava** will be seen passing from the dorsal body-wall to the dorsal aspect of the liver. Follow it from here to the pericardium.

> Is there any muscular diaphragm, or a septum transversum comparable with that of the dogfish? (11)

At an early stage of development an epiploic foramen is found just caudal to that part of the posterior vena cava which is contained in the mesohepar; it constitutes the one opening of the omental bursa into the pleuro-peritoneal cavity. This later becomes closed by the union of the mesohepar (caval mesentery) and mesentery of the intestine. This structural change does not occur in mammals (p. 127, cf. also p. 71).

Identify the **anterior mesenteric vein** on the left side of the intestinal mesentery. The **pancreas** is situated close to this vein as the latter approaches the duodenum.

On each side of the dorsal attachment of the intestinal mesentery identify the mesenteries of the gonads. They are known as **mesorchia** in the *male*, and as **mesovaria** in the *female*. Identify the testis, or ovary.

Lateral to the mesorchium of the *male* a convoluted tube will be seen. This is the **ductus deferens**. Fine **vasa efferentia** pass in the mesorchium from the testis to ductus

deferens. A slender pigmented tube runs forwards beside the dorsal aorta. This is the ill-developed **Müllerian duct,** which attains its full development only in the female.

In the *female,* lateral to the mesovarium, identify the **Müllerian duct**, whose anterior opening is far forward near the septum transversum. If the ovary is large a considerable part of it may be removed with advantage.

Identify the **splenic artery** running from the region of the pancreas to the spleen in a small mesentery (a remnant of the dorsal mesogastrium) which is attached to the left side of the mesentery of the liver and intestine. The splenic artery arises from the **coeliacomesenteric axis** by a common stem with the **hepatic artery**. Accompanying the splenic artery there is a **splenic vein**, which joins the anterior mesenteric vein to form the (**hepatic**) **portal vein.** Follow the portal vein and hepatic artery to the liver.

Find the **gastric artery**; it reaches the fore-part of the stomach on its left side.

Open up one of the lungs and follow the cavity up to the bifurcation of the trachea.

> Are there any cartilaginous rings in the walls of the trachea? (cf. microscopic sections).

Pelvic Region.

Remove the large glandular structure which is situated beside the cloaca. Two muscles will be seen to extend from the mid-line of the pelvis into the ventral aspect of the hind-limb. The more posterior, the **flexor cruris**, extends along the hinder aspect of the thigh to gain an insertion on the proximal end of the tibia (and on the calf musculature). The more anterior muscle, the **M. pubi-ischio-femoralis externus**, is triangular; it is inserted along a line on the ventral aspect of the femur which ends proxi-

mally in a prominence, the **internal trochanter** (to be examined later). Define the antero-lateral margin of this muscle, and expose the margin of the pubis. The rectus (abdominis) muscle is attached here.

Lateral to the two above-mentioned thigh muscles there is a long muscle, the **pectineus**. On careful dissection this can be shewn to pass through the abdominal wall between the pelvis and the abdominal musculature. Detach the abdominal musculature from the margin of the pubis on the medial side of the pectineus, and follow the latter to its origin on the *deep* aspect of the pubis.

Divide it at the pelvic margin and reflect it distally. It is inserted on the dorsal aspect of the femur in nearly its whole length.

The **ilium** extends dorsally into the body-wall above the hip-joint and articulates with the vertebral column.

Is there any similar structure in the dogfish?

The external oblique muscle is attached to its anterior margin. Detach this muscle.

The superficial dorsal thigh musculature takes origin from the lower part of the ilium, and passes beyond the knee-joint. The main part is an (**extensor**) **iliotibialis**, while on the fibular side there is a slender **iliofibularis**. *Detach* these from the ilium and reflect them distally, but before doing so identify the **femoral nerve** which is **pro-zonal** in its course and enters the thigh between the extensor iliotibialis and the pectineus.

The **peroneal nerve** and the **sciatic artery** will thus be brought into view, the former gaining the extensor (anterior) aspect of the leg and dorsum of the foot by passing between the iliofibularis and extensor iliotibialis.

Examine the flexor cruris muscle once more. It is joined

on its hinder margin, near the pelvis, by a **caudocrural muscle** which takes origin in the tail.

Detach this muscle from the flexor cruris. Another muscle passing from the caudal vertebrae to the thigh will thus be exposed, the **caudofemoralis**. The **ventral sciatic nerve**[1] passes ventrally to this muscle, near its femoral attachment, to be distributed in part to the flexor cruris.

The **tibial nerve** is situated very close to the sciatic artery, and is distributed on the ventral or flexor aspect of the leg and foot.

Detach the pubi-ischio-femoralis externus from the femur and reflect it proximally. As you do so, there will appear a very fine nerve which enters its deep aspect after passing through the **obturator foramen** in the ventral part of the os coxae (about three millimetres from the acetabulum). This nerve, **N. obturatorius**, is thus diazonal in its course.

Identify the internal trochanter. Notice that there is no lesser trochanter in the neighbourhood of the insertion of the pectineus (contrast mammals, p. 115).

Open the ventral aspect of the hip-joint. Contrast the forms of the articular surfaces with those of the corresponding joint in the dogfish.

> Can you see any ligamentum teres? (12)
>
> Is there a patella at the knee? (13)
>
> Can you recognise any heel-prominence comparable with that formed by the tuber calcanei in mammals?

Make an incision through the pelvis in the mid-ventral line, and backwards as far as the anterior cloacal wall. Turn the os coxae laterally so as to display the hinder part of the peritoneal cavity.

[1] Appleton, *Journ. Anat.* 62, 1928.

Can you recognise any ventral abdominal vein?

The **common iliac artery** and **vein** run ventrally towards the hip-joint round the side of the peritoneal cavity. Each provides a large branch for the ventral abdominal wall, the **posterior epigastric vessels**. The vein joins the **renal portal vein**, which will be found running along the lateral margin of the kidney (**opisthonephros**). Find the opisthonephric ducts of the female, which drain the kidneys. A similar vessel in the male is continued forwards as the ductus deferens.

In the mid-ventral line will be seen the **bladder**. Cut open the rectum (hinder part of the intestine) and cloaca by an incision along their side-walls. Find the opening of bladder into the cloaca.

Follow the Müllerian ducts of the *female*, and the opisthonephric ducts of both sexes, back to the cloaca.

What is the relation of their openings to that of the rectum?

Observe that there is no distinct metanephros comparable with the permanent kidney of mammals (e.g. Man).

Follow the renal portal vein caudally. It joins its fellow to form the **caudal vein**.

Brain.

Find the **olfactory nerve** as it passes from the olfactory foramen to the olfactory (nasal) sac. Working from this foramen, remove the cranial roof, keeping above the level of the deep ophthalmic nerve.

Identify the **cerebral hemispheres**, with long **olfactory tracts** extending forwards, the mid-brain (in which

there is only a faint indication of a distinction between the right and left optic lobes), the **pineal** (or epiphysis) extending forward over the interval between the cerebral hemispheres, the **medulla** and **fourth ventricle**. Notice that no well-defined cerebellum is seen on external examination. Observe the pigmentation of the **meninges**. Follow the optic, fifth and seventh, the auditory, the glossopharyngeal and vagus nerves to the brain.

Remove the brain, and identify the **hypophysis.**

Subphylum: CRANIOTA.
Branch: GNATHOSTOMATA.
Grade: *TETRAPODA*.
Subgrade: AMNIOTA.
Class: REPTILIA.
Order: SQUAMATA.
Suborder: LACERTILIA.
Family: LACERTIDAE.
Genus and Species: *Lacerta viridis*.

The Green Lizard.

This animal lives in central and southern Europe and in south-west Asia. Various species of the genus occur in all continents but Australia. The Order Lacertilia is one of the most recently evolved reptilian Groups. Most of the modern Families are not represented among the known fossils of the Mesozoic period; they are first found in the Tertiary rocks. Some Lacertilia have, however, been found in the Mesozoic era, even as far back as the Triassic period.

Ophidia (comprising the snakes), which form the other Suborder of the Squamata, are likewise of comparatively recent origin, and have probably been evolved from animals of lacertilian pattern.

The Lacertilia are very unlike the earliest reptiles, which are known from rocks dating from so early a period as the Carboniferous. These were heavily built animals, resembling their forerunners the Stegocephalia in general form. Besides the evident skeletal modification seen in Lacertilia, extensive alterations (cf. p. xv) have clearly occurred in the vascular, muscular and nervous systems.

The Family Lacertidae comprises some of the less modified members of the Lacertilia. A number of Lacertilia have undergone modifications of the tail and limbs, in relation to an arboreal, swimming or cursorial habit, while

the limbs have been completely lost in the Amphisbaenidae, which thus present an outward resemblance to snakes.

External Examination.

Notice the covering of **epidermal scales**, the greater definition of the neck than in *Necturus*, the relatively great length of the fourth digit on each hand and foot, and the presence of a pair of tympanic membranes (present in the frog but wanting in *Necturus*). These membranes are situated about half an inch behind the eyes. Notice how close they are to the general surface of the head. A distinct neck-region is more evident than in *Necturus*.

There are no external gills, nor branchial clefts.

> How many phalanges are there in the various digits?

Dissection.

Remove the skin from the surface of the animal, on one side, from the fore-limb and from this region forwards. Notice its close connection to the cranium. The tympanic membrane will probably come away with the skin. A thin **sphincter colli** will be found, the anterior part with lateral attachments to the mandible being distinguished (as in *Necturus*) as the **mylohyoid**. *Reflect* this musculature laterally and dorsally, and notice branches of spinal nerves which enter it. Between the sphincter colli and the hinder margin of the tympanic membrane will be seen the **depressor mandibulae**.

Below the tympanic membrane the relatively enormous **pterygoid muscle** will be seen overlapping the lower margin of the hinder end of the mandible.

The **adductor externus**[1] extends upwards from the hinder part of the mandible, under cover of a strong liga-

[1] Lakjer's name (1926).

ment which joins the zygomatic (jugal or malar) bone to the quadrate. The latter bone provides attachment for a part of the tympanic membrane.

Behind the depressor mandibulae, the side-wall of the pharynx is close to the surface, the lateral expansions of the pharynx being known as the **pyriform recesses**. Two slender **cornua** of the **hyoid** apparatus will be seen passing nearly vertically across it, and, just caudal to the hinder of them, the **hypoglossal nerve**. If the latter is followed dorsally it will be found to disappear under cover of the **M. trapezius anterior**. If followed more ventrally it will be found to cross superficially to the hinder cornu of the hyoid, and to disappear under cover of hypobranchial musculature which connects the two cornua with the mandible. These cornua represent respectively the hyoid arch and first branchial arch of the dogfish and *Necturus*.

Detach M. depressor mandibulae from the jaw, and reflect it upwards. Fine branches of the facial nerve will be displayed, one of them supplying this muscle. Remove M. depressor mandibulae.

M. trapezius anterior is a triangular muscle, much larger than in *Necturus*. Ascertain its attachments, *reflect* it dorsally and remove it.

Extending forwards from the shoulder-girdle to the hyoid apparatus there is a broad muscle-sheet, the more medial part of which is distinguished as the (**epi**) **sterno-hyoid**, the more lateral part as the **omohyoid**. A nerve, the **descendens hypoglossi**, will be seen to leave the hypoglossal nerve and run down the hinder part of the wall of the pyriform recess and disappear under cover of these muscles (which it supplies). Identify the **trachea**.

M. trapezius posterior is a triangular muscle, extend-

ing across the scapula from the fascia covering **M. sacro-spinalis** (behind the level of the fore-limb) to the anterior margin of the scapula.

Detach it from the scapula and reflect it dorsally.

Identify **Mm. dorsalis scapulae**[1] and **latissimus dorsi**, similar to those of *Necturus*.

Reflect **M. pectoralis** towards the humerus, commencing at its axillary margin.

Where does it take origin?

Examine the insertion of latissimus dorsi. It reaches the humerus by passing on the deep (ventral) side of the **scapular head of anconaeus**. Detach the latter from the scapula, and identify the **radial nerve**, as it passes across the dorsal aspect of the arm, superficially to the humeral head of M. anconaeus. This nerve will be seen to pass ventrally to the tendon of insertion of latissimus dorsi.

Cut through latissimus dorsi, and reflect the dorsalis scapulae downwards towards its insertion. Identify the **axillary nerve**, which passes forwards deep to the dorsalis scapulae close to the shoulder-joint.

Antero-ventrally to the shoulder-joint there are several small muscles. Behind them, medial to the shoulder-joint, one can now see the intermediate tendon of **M. biceps brachii**. The most anterior of the small muscles is the **deltoid muscle**, which is inserted on the humerus close to M. pectoralis. It extends forwards, first being *deep* to the **clavicle**, and further forwards deep to the sternohyoid muscle. Examine its origin by detaching the clavicle from the scapula, and removing the greater part of the clavicle.

Verify the distribution of the axillary nerve to the deltoid

[1] This muscle is also known as the 'scapular head of the deltoid'.

muscle. *Detach* the deltoid muscle from the humerus and then remove it.

The **supracoracoid muscle** is behind the deltoid muscle (being overlapped by it). Detach this muscle from the humerus, and find the **supracoracoid nerve** which enters its deep surface from the supracoracoid foramen.

Is the biceps attached to the interclavicle or to the coracoidal part of the limb-girdle?

Examine the movements of the shoulder-girdle. The median part, the interclavicle, is practically immobile, being attached behind to the sternum. The **scapulo-coracoid part** of each side is on the other hand very mobile, and the clavicle serves as a connecting rod with the interclavicle.

In what directions do you think the principal movements occur?

An extensive **serratus muscle** connects the scapula to the trunk. The most anterior part extends forwards to gain an attachment in the neck (cf. the human M. levator scapulae).

What muscles control the movements of the scapulocoracoid?

Detach the serratus muscle from the scapula, and lift the latter away from the body-wall. Identify the **internal jugular vein** (which passes forwards dorsally to the hypoglossal nerve).

Is the relation to this nerve similar in Man?

Identify the brachial plexus, and the subclavian vein which joins the internal jugular close to the anterior margin of the scapula.

Cut through the internal jugular vein and turn it forwards. Identify the **vagus nerve** and **internal carotid artery**.

Turning the girdle still more laterally, identify the **subscapularis muscle** on the deep aspect of the coracoidal part of the girdle. One can also see the **coracoid head of the anconaeus**.

> Do the brachial artery and the long inferior brachial nerve pass between this head and the scapular head, as in *Necturus*? (1)

Medial to the coracoidal part of the girdle will be seen the side wall of the **pericardium**.

Identify the **long inferior brachial nerve**. It is on the medial aspect of the arm, in the groove between the **coracobrachialis** and the **anconaeus**. An **ulnar nerve** leaves it in the proximal part of the arm, and passes dorsally to the medial epicondyle, between the latter and the olecranon.

> Is there a similar nerve in *Necturus*? (2)

Examine the lateral margin of M. anconaeus. A cutaneous branch of the axillary nerve runs distally along this margin, in company with the **cephalic vein**. A narrow strip of **M. brachialis (inferior)** is visible between this vein and the biceps muscle. Examine the origin of the long inferior brachial and radial nerves from the plexus.

Detach the biceps from the girdle and reflect it distally.

> What is the relation of the long inferior brachial nerve to the insertion of biceps in the forearm? Compare this relation with that of the mammalian median nerve.

Deep Dissection of the Head.

The **adductor externus** disappears under cover of a bony temporal roof as it passes dorsally. *Remove* this roof.

> Does any part of the muscle take origin from the roof? (3)

Lay open the **temporal fossa** by removing the anterior wall of the tympanic cavity and the postorbital bar. Just behind the eye an intermuscular interval is to be found. The **maxillary nerve** will be seen emerging from this interval; it then passes below the orbital structures.

The muscle on the medial side of the interval is the **pseudotemporalis**.

> Compare the muscular relations of the maxillary nerve in the lizard with those seen in *Necturus*.

Open up the interval and remove M. adductor externus, which bounds it laterally. Detach this muscle from the mandible and remove it. If this procedure is completely carried out the **mandibular nerve** will be laid bare. Follow it to the region of lower jaw.

Examine the interval between the eyeball and interorbital septum. Identify the **ophthalmic nerve**. In the temporal fossa it is placed deeply to a muscle-mass which is concealed by M. pseudotemporalis. Remove the latter. The muscle-mass so exposed is the representative of the M. levator palatoquadrati of the dogfish. Its lower attachment will be found on the palatopterygoid bar, which is movable in the lizard as in most bony fish. This bar corresponds in part to the palatoquadrate bar of the dogfish.

> Is the pterygoid bone movable on the cranium in *Necturus*? (4)

Identify the **epipterygoid (columella cranii)**.

> What are the relations of the various divisions of the trigeminal nerve to this bone? (5)

Notice the great extent of the temporal fossa, and contrast this with the narrow cranial cavity.

Examine the dorsal musculature immediately behind the head. A **splenius muscle** passes obliquely round the side of the neck to gain attachment to the base of the skull. [**M. semispinalis** is a thick muscle deep to it, extending from the vertebral column to the dorsal part of the hinder aspect of the skull. Reflect these muscles. A small **M. obliquus** will be seen under cover of semispinalis.]

Remove the roof of the cranial cavity. Identify the **cerebral hemispheres** and **olfactory tracts**, the well-defined **optic lobes**, **medulla** and **fourth ventricle**, and the small **cerebellum** at the fore-end of this ventricle.

Thorax and Abdomen.

The brachial plexus emerges in the angle between the **M. obliquus externus** (dorsally), and the lateral margin of the sternum (medially). Identify the first **costal cartilage**, which joins the sternum from behind. Remove the skin from the trunk as far back as the anterior margin of the pubis. Cut through the costal cartilages of one side, and then continue the incision along the ventral abdominal wall through musculature and peritoneum, a little to one side of the mid-ventral line.

Identify the **ventral abdominal vein**, the **liver**, and **gall-bladder**.

> Is there a falciform ligament?

Separate the sternum and interclavicle from the under-

lying structures and cut through them in the mid-ventral line. *Remove* the detached portion.

The **posterior vena cava** can now be seen passing for wards from the liver to the pericardium.

Cut away the abdominal wall of one side, cut through the falciform ligament, and then cut away also the more ventral part of the abdominal wall on the *opposite* side of the body (if this has not previously been dissected).

Identify the **lungs**.

> What difference do you observe in the mesenteric attachments of the two lungs?
>
> Are there pleural cavities distinct from the peritoneal cavity?

If the dissection is being carried out on the *right* side, lift the liver a little ventrally and examine the interval between the right lung and the liver. Dissectors of the *left* side should now proceed as directed below.

Identify the transparent **mesohepar (caval mesentery)**. Through this it is possible to see the omental lobe of the liver. The posterior vena cava enters the liver near the end of the right lobe. Cut this lobe off, near its extremity, and then cut through the mesohepar on the ventral side of the lung. The space which is thus opened is the **omental bursa**. This is bounded on the left by the **lesser omentum** (attached to liver and stomach), and, dorsally to the stomach, by the **dorsal mesogastrium**.

The lesser omentum ends caudally in a free margin, in which one will find the **pancreas** and **portal vein**. Identify the **epiploic** foramen.

Dissectors of the *left* side should lift the liver ventrally, and identify in the first place the **lesser omentum**.

The structures which have been described above for dissectors of the right side can now be examined by cutting through the lesser omentum, preserving only its hinder margin, which contains the **pancreas**.

Is the **spleen** in the dorsal mesogastrium?

In the *male*, identify the **testis** and **mesorchium**. An elongated **epididymis** lies to the lateral side of the mesorchium, and is provided with a short mesentery.

In the *female*, the ovaries will be found extending backwards into the pelvic cavity. Identify the Müllerian duct, and find its anterior termination.

Examination of the pelvic cavity must be postponed till the hind-limbs have been dissected (p. 76).

Pericardium.

Open the pericardium. Identify the **ventricle** and two **atria** (**auricles**). In the groove between the latter will be found the three arterial trunks which leave the heart, arranged round one another in a spiral fashion. These are the **pulmonary artery** and the two **aortic** (systemic) **arches**.

Find the precaval vein (**anterior vena cava**) of one side, and the **posterior vena cava**. Follow the **pulmonary vein** of one lung into the **left atrium**. Identify the **sinus venosus**.

Working from the fore-end of the pericardium, examine the distribution, at the root of the neck, of the two aortic arches. Both **internal carotid arteries** arise from the *right* aortic arch. Divide the precaval vein and follow the

aortic arch in its course to the dorsal aspect of the oesophagus, where it joins its fellow of the other side.

> Is the internal carotid artery connected to the aortic arch by a **ductus caroticus**?
>
> From which aortic arch does the *left* subclavian artery arise? (6)

Pharynx.

With scissors cut backwards from the angle of the mouth through the side-wall of the pharynx and oesophagus. In the floor of the mouth identify the tongue.

> Does this appear to be a muscular structure?

Just behind the tongue will be seen the **aperture of the larynx**. Cut away the lower jaw of one side (only if the other side of the head has *not* been previously dissected). Inspect the interior of the pharynx. On the medial aspect of the hinder end of the lower jaw there will be observed a large prominence. This is formed by the **pterygoid muscle**.

Dorsal to this prominence will be seen a narrow cleft which widens out posteriorly. This cleft leads into the **tympanic cavity** and the **recessus piriformis**, which are practically continuous with one another.

In the roof of the mouth identify the **internal nares**. These are situated in the upper part of the cavity of the mouth. Observe that this part of the oral cavity is partly separated off from the lower part by a pair of **palatal folds**, which project medially from the lateral walls. This upper part of the cavity corresponds to the **nasopharyngeal canal** of mammals; and the folds are similar to the palatal folds which have only a temporary existence as such in the mammalian embryo, since they subsequently fuse in the mid-line to form the palate.

Hind-limb.

Remove the skin from the hind-limb and adjacent part of the body. Detach the musculature of the abdominal wall from the pubis. Two muscles belonging to the thigh will be seen to extend on to the ventral aspect of the pubis under cover of the abdominal musculature. The more lateral muscle is the **pectineus**, the more medial the **pubi-ischio-femoralis externus** (**obturator externus**). The pectineus enters the thigh on the lateral side of the **pubic tubercle** (proc. lateralis), to which the external oblique muscle gains attachment. It does not reach far into the thigh, being attached to the dorsal aspect near the proximal end. Nearly in line with it, in the thigh, will be seen the **ambiens muscle**, a muscle peculiar to reptiles. Find its insertion in the region of the knee. The insertion of pectineus on the femur is placed to the lateral side of the ambiens.

> Is this relation to ambiens comparable to the relation of pectineus to M. rectus femoris in mammals? (7)

On the medial side of ambiens identify the **sartorius.** This consists of superficial and deep portions, the latter passing deeply into the popliteal space to reach its insertion.

On the caudal side of the sartorius there is a large muscle-mass (**pubi-ischio-tibialis**), comprising imperfectly differentiated **gracilis** and **flexor cruris** muscles.

The proximal end of the ambiens muscle is separated from the (**extensor**) **iliotibialis**[1] by the femoral attachment of pectineus. On the caudal side of the iliotibialis is

[1] The application of the term 'iliotibialis' to the mammalian M. sartorius should be discontinued; primitively in mammals the sartorius has no iliac attachment.

the **iliofibularis**. Identify the **peroneal nerve**, which appears close to the knee in the interval between these two muscles.

Taking care not to injure the peroneal nerve, detach the iliotibialis and iliofibularis from their distal attachments and reflect them proximally.

> What is attached to the backwardly directed process of the ilium?

M. iliofemoralis is now exposed, passing from the ilium to the proximal part of the femur just lateral to the pectineus. It is a mere rudiment in *Necturus*. In mammals it has become greatly elaborated to form the gluteal musculature.

Identify the **femoral nerve**.

Cut flexor cruris and gracilis from their attachments in the leg, and reflect them proximally. Identify the tendon of **M. caudofemoralis**, passing over the ventral aspect of the femur near its proximal end.

Reflect ambiens proximally. Deep to it will be seen the **vastus muscle**.

> Is there a vastus muscle in *Necturus*?

Examine the insertion of the obturator externus. A conspicuous **internal trochanter** will be found.

> Is there a lesser trochanter, as in mammals?
> Is any part of the attachment of M. flexor cruris lateral to the superficial calf musculature, like that of the mammalian biceps femoris? (8)

M. caudofemoralis enters the tail by passing under cover of M. flexor cruris. Both are attached to caudal vertebrae, the latter also to the ilium and ischium between which it is

partially interrupted by a tendinous intersection. Expose the whole length of M. caudofemoralis.

Does it intervene between the **tibial** and **ventral sciatic nerves** as in *Necturus*?

What is the action of this muscle?

Pelvic Cavity.

Cut through the pubic and ischiadic symphyses, and turn one os coxae laterally. At the hinder end of the pelvic cavity there will be found a reddish **metanephros** (kidney) on each side.

In the *male* the epididymis is continued caudally into the **ductus deferens**. In the *female* the Müllerian duct should be followed to its opening into the cloaca.

Can you see any bladder?

Subphylum: CRANIOTA.
Branch: GNATHOSTOMATA.
Grade: *TETRAPODA*.
Subgrade: AMNIOTA.
Class: MAMMALIA.
Subclass: EUTHERIA.
Order: CARNIVORA.
Suborder: FISSIPEDIA.
Genus and Species: *Canis familiaris*.

The Dog.

The Order Carnivora had become distinct from other Eutherian Orders by the commencement of the Tertiary period, at which time we find it represented by the Suborder of Creodonta. These animals retained a primitive eutherian kind of limbs, but they diverged from their near relatives in modifications related to a predatory habit and carnivorous diet.

Modern Carnivora are probably all derived from one section of the Creodonta known as Eucreodi (Miacidae) in which a specialisation of the fourth upper premolar and of the first lower molar as a pair of shearing or **carnassial** teeth deserves notice. In these animals, moreover, the brain was large in comparison with most contemporary mammals of similar size.

The modern Carnivora have undergone modifications of various kinds; some have undergone a marked specialisation of the middle ear (e.g. the cat and its relatives), while divergences in respect of the teeth and external genitals have made their appearance. One section, the Suborder Pinnipedia (e.g. the seals) have undergone considerable

structural modifications in relation with an aquatic habit of life.

The cerebral hemispheres of modern Carnivora present a considerable development in comparison with the early Tertiary Carnivora, and the limbs have undergone modifications related to a cursorial habit of life, such as reduction of clavicle and of the third trochanter, features correlated with muscular and locomotor alterations. In most Miacidae we find both the clavicle and third trochanter well developed. The tarsus and carpus also shew changes, the navicular (scaphoid), lunate (semilunar) and centrale being joined into one bone in the adults of modern Carnivora. Many of the modern Carnivora (exemplified in the dog) have become digitigrade, and the palm of the hand and sole of the foot are accordingly no longer naked of hair, as they are in plantigrade forms. With this change the hallux and pollex have suffered retrogression, and a number of **vestigial** muscles are found in the limbs.

Members of certain mammalian Orders (e.g. Artiodactyla, Perissodactyla, Litopterna) present more extensive changes connected with development of the habit of running on the terminal phalanges of the digits, such as loss of the movement of supination, and a more extensive reduction of digits, exemplified in the horse and cattle.

Minor points of divergence among modern Carnivora comprise a sporadic loss of the alisphenoid canal (p. 86) and of the entepicondylar foramen (p. 102) and the occasional development of a postorbital bar (e.g. in the mongoose).

External Examination.

Investigate the following features:

What parts of the body are hairless?

How does the upper lip differ from that of the rabbit?

How many pairs of nipples are there?

Are there any digits which do not reach the ground in ordinary locomotion?

Five callosities will be seen on each hand and foot; the relation of these to tendons and joints will be seen in the course of the dissection.

Observations should be made on living animals in regard to the limb-movements during locomotion. The limbs move in nearly vertical planes, parallel to the median sagittal plane of the body, except when the animal is changing direction.

How do you think the limb-movements would differ from those of the lizard?

Is the movement in the shoulder-region mainly between the scapula and chest-wall or is it mainly at the shoulder-joint? (1)

How does the form of the thorax differ from that of Man?

Between the lips and the teeth there is a considerable potential space, the **vestibulum oris**.

Did you see such a space in the lizard?

In the Museum, examine the external ear of aquatic mammals.

Is there a more marked differentiation between the sexes of the dog in regard to the external genitals than in the lizard?

Notice the presence of a **perineum** separating the anal and urogenital parts of the mammalian cloaca. Cloacal openings, with the exception of the male penis, are found directed towards the caudal aspect of the body, whereas in most reptiles, exemplified in the lizard, the cloaca opens ventrally. Observe also the narrowing of the tail in all diameters as compared with that of the lizard; it is related to a radical change in the mechanism of thigh-retraction (p. 114).

Review the external features exhibited by the dog which distinguish it from the lizard.

Head and Neck.

In making the skin incisions, take care not to cut deeply owing to the risk of cutting superficial musculature and nerves.

If no previous dissection of the head and neck has been carried out, the *right* side should be dissected.

Incisions:

1. Mid-ventral line, from fore-end of sternum to symphysis menti.

2. From hinder end of Inc. 1 to mid-dorsal line, just behind the head, passing in front of the shoulder.

3. From dorsal end of Inc. 2 to angle of mouth, passing just behind the pinna (external ear), and then continued along the margin of the mandible to meet Inc. 1.

Reflect the skin for a short distance forwards from Inc. 2. Examine its deep surface. A thin sheet of cutaneous musculature (**platysma**) will probably be found to have been turned forward with the skin. Separate this musculature from the skin and continue to turn the skin forwards

till the whole area marked out by the incisions has been removed.

Incisions:

4. Carry the knife round the pinna, close to its base.

5. Around the margin of the orbit.

6. From Inc. 3, near the angle of the mouth, to the side of the nostril, just above the margin of the upper lip.

7. Mid-dorsal line of head, from dorsal end of Inc. 2 to the nose, then joining the fore-end of Inc. 6.

Reflect the piece of skin marked out by these incisions, leaving the pinna and eyelids undisturbed.

The platysma is continuous with a **M. risorius**, passing to the angle of the mouth. **M. zygomaticus** is thin, passing upwards and backwards from the hinder part of the upper lip. A muscle like the human M. quadratus labii superioris extending dorso-caudally from the fore-part of the upper lip, is conspicuously thick.

The external ear-muscles are well developed. [Notice the **middle levator** passing antero-medially from the large **concha** of the pinna to the sagittal crest of the skull. **Long** and **short abductors** pass backwards from the concha to the occipital bone and **ligamentum nuchae**.] The **long inferior** auricular muscle extends backwards to the fascia covering the larynx.

[*Reflect* the abductor muscles from behind. A cutaneous branch of the **first occipital nerve** passes through them to reach the pinna.]

Reflect M. auricularis inferior longus from behind. Entering its deep aspect is the large **cervical** division of the **facial nerve** (about one inch from the concha). Preserve

this nerve. *Reflect* Mm. risorius and zygomaticus from behind; slender branches of the facial nerve enter them.

> Had the facial nerve in the lizard a similar extensive distribution to facial muscles? (2)

Identify the **hyoid bone** and **zygomatic arch**. Above the latter the cranium is covered on each side by the **temporal muscle**; below it the mandible is covered by the **masseter muscle**. The floor of the mouth from the hyoid bone forwards is supported by the **mylohyoid muscle**.

Identify the large **submaxillary** salivary gland, just below the pinna. The **external maxillary** and **external jugular veins** course respectively below and behind it. The former vein joins the latter close to the gland. Follow the former vein forwards to a groove between the angle of the mouth and the anterior margin of the masseter, where it is joined by the **external maxillary artery** (which comes from below the margin of the mandible).

The side-wall of the vestibule behind the angle of the mouth contains the thick **buccinator muscle**.

On each side of the external maxillary vein identify the submaxillary **lymph-glands**.

Between the submaxillary gland and pinna find the **parotid gland**. At its lower margin the external jugular vein is formed by the union of **posterior auricular** and **internal maxillary veins**, the latter emerging from deep to the gland.

Two large bundles of the facial nerve pass forwards towards the angle of the mouth, one just below the zygomatic arch, the other near the lower margin of the masseter.

About midway between them is the **parotid (Stenson's) duct.**

> Opposite which tooth does it enter the mouth? (3) Is this relation similar to that in Man? In the rabbit it opens opposite the last molar, in the cat opposite the last premolar tooth.

Taking care of adjacent veins, raise the submaxillary salivary gland from its bed, starting at its hinder margin. Deep to it identify the large **digastric muscle**, crossed superficially by the thin **stylohyoid muscle**. Follow the digastric muscle to its insertion.

> How does this insertion differ from that seen in Man? In the cat and rabbit it is innervated solely from the facial nerve. In the course of the subsequent dissection ascertain whether this is so in the dog (4).
>
> Does the **external maxillary artery** pass deep to the digastric as in Man?

The duct of the submaxillary gland (Wharton's duct) passes forwards from the deep aspect of the gland, and above the digastric muscle.

Cut the duct and remove the gland. Turn the parotid gland forwards from behind, and find the **posterior auricular nerve and artery** emerging from its deep aspect. The largest sensory nerve of the pinna, the **great auricular nerve**, crosses this artery.

Remove the parotid gland piecemeal, and follow branches of the facial nerve through it to the **stylomastoid foramen**, separating the concha from the side of the head.

Cut through the external auditory meatus and remove the pinna. Separate the lower margin of the digastric

muscle from underlying structures. Deep to its lower margin is the **hypoglossal nerve.** This nerve proceeds deep to the mylohyoid muscle.

> Is this relation seen also in Man (the cat or rabbit)?

Close to the hypoglossal nerve find the **lingual artery,** which disappears from view just before reaching the mylohyoid by passing deep to **M. hyoglossus.**

> Is this arrangement similar to that in Man?

Detach the digastric from the mandible, and cut it off close to the cranium.

> Where is its posterior attachment on the cranium? (compare with cleaned skull) (5)

The **external carotid artery** passes deep to digastric, and is here superficial to **M. styloglossus,** a relatively large muscle.

> What is the action of the styloglossus?

Find the origins of the lingual and external maxillary arteries.

> Are the relations of the hypoglossal nerve to the digastric muscle and external carotid artery similar to those found in Man (the cat or rabbit)?

Temporal Region.

Cut through the masseter along the lower edge of the zygomatic arch, and then remove it. Just below the **temporomandibular joint** find the terminal division of the external carotid artery into **superficial temporal** and **internal maxillary arteries.** Find the **auriculotemporal nerve** just behind the former artery. Cut them both and turn them downwards.

To *reflect* the temporal muscle, first examine the region between the eye and temporal muscle.

> Is there a complete postorbital bar? There is not one in the rabbit, nor in the cat.

Cut through the fascia along the whole length of the upper margin of the zygomatic arch. Find the **fronto-zygomatic ligament** which superficially separates the orbit and temporal fossa. Cut through the deep fascia just behind this ligament, and explore the fascial space between the orbital structures (which are enclosed in a **fascia periorbitalis**) and the temporal muscle.

Cut through the zygomatic arch at its *extreme* fore- and hind-ends.

> Where is the temporal muscle attached on the mandible?

As the dissection proceeds attention should be paid to the relative positions of structures which in Man respectively occupy the pterygopalatine (sphenomaxillary) fossa, the orbit, the pterygoid region and temporal fossa.

Cut through the mandible immediately in front of the coronoid process. *Cut* through the coronoid process, detaching it with the temporal muscle from the jaw. Identify the **maxillary nerve** and **internal maxillary artery**, lying on the surface of the **internal pterygoid muscle**. (In the cat a large external pterygoid muscle is visible above the internal pterygoid muscle, while in the rabbit the external pterygoid almost completely conceals the internal pterygoid, and both are at a lower level than the maxillary nerve.) Carry the knife forwards on the deep aspect of the mandible, keeping close to the bone. The internal pterygoid muscle, and the hinder part of the

mylohyoid muscle will be cut, also the **inferior alveolar vessels** and **nerve** close to the foramen by which they enter the mandible.

Disarticulate the temporomandibular joint, taking care not to injure the **internal maxillary artery** and **auriculotemporal nerve**. The **external pterygoid muscle** will be found attached to the neck of the mandible, and must be detached.

Find the **buccinator nerve**, a sensory branch of the mandibular division of the trigeminal nerve.

The inferior alveolar nerve will be found, cut short, lying on the internal pterygoid muscle. Just anterior to it is the **lingual nerve**.

> Are the relations of the lingual nerve to the internal pterygoid and mylohyoid muscles similar to those seen in Man?
>
> Does the internal maxillary artery pursue a course relative to the lingual and inferior alveolar nerves which is similar to that of the human artery? (6)

Find the entrance of the internal maxillary artery[1] into the **alisphenoid** (alar) **canal**. (In the cat and the rabbit it does not become enclosed in an alisphenoid canal.)

Immediately before entering this canal it gives off a **middle meningeal artery** which enters the cranium with the mandibular nerve.

> On the cleaned skull identify the **foramen ovale**, and ascertain whether there is a separate foramen (spinosum) for the passage of the middle meningeal artery. (7)

[1] The name of 'external carotid' employed by Turner (1848) cannot any longer properly be applied to this vessel.

Lift up the inferior alveolar nerve. The **chorda tympani nerve** passes deep to it and deep to the internal maxillary artery, and then joins the lingual nerve.

The **periorbital fascia** encloses the orbital structures and is fixed superficially to the margins of the orbit.

In the angle between the periorbital fascia and the internal pterygoid muscle identify the internal maxillary artery as it emerges from the alisphenoid canal, and, just deep to it, the maxillary nerve. On the cleaned skull ascertain the relation of the **foramen rotundum** to the alisphenoid canal.

Occupying the space between the periorbital fascia and the fore-end of the zygomatic arch is the **zygomatic gland**[1] which covers a part of the internal pterygoid muscle. Find the duct, which opens close to the third upper molar tooth.

Remove this gland, cutting the duct with care to avoid injury to the maxillary nerve.

In the following dissection, continual reference must be made to a cleaned skull for the relative positions of foramina. Cut away a portion of the buccinator muscle opposite to the *molar* teeth. With pliers *remove* the superficial wall of the infra-orbital canal, also the upper molar teeth with the supporting alveolar margin.

The **internal maxillary artery** divides into an **infra-orbital artery** (which accompanies the **infraorbital nerve**), and the **great palatine artery**, which passes towards the posterior palatine canal. With the latter artery are filaments of the maxillary nerve. Just above these structures, on the lateral aspect of the internal pterygoid

[1] In the cat and rabbit the corresponding gland is usually described as the 'infraorbital' gland.

muscle will be seen the elongated **sphenopalatine ganglion**. This is joined at its supero-caudal end by the slender **Vidian nerve** (also known in Man as the 'nerve of the pterygoid canal'). Ascertain by which foramen this nerve leaves the cranium.

Define the origin of the internal pterygoid muscle. Immediately above it is the origin of the **inferior oblique muscle** of the orbit. Turn up the lower margin of the fore-end of the internal pterygoid muscle, and find the **naso-palatine branch** of the great palatine artery, which passes to the nasal fossa by the **sphenopalatine foramen**. Follow the great palatine artery to the hard palate, with branches of the maxillary nerve, by removing bone.

Lift up the infraorbital nerve as it lies in the infraorbital canal. Find the **anterior superior alveolar nerve**, entering a foramen on the medial wall of the canal. Follow it forwards.

> Does it innervate any part of the nasal fossa as in Man? (8)

Orbit.

Besides the orbital muscles which are to be found in a dogfish or in Man, there will be found in the dog a **M. retractor oculi**, comprising a series of short bellies adjacent to the optic nerve. They are innervated from the abducens nerve.

Make an incision in the caudolateral aspect of the periorbital fascia, and turn the cut margins away from the subjacent orbital structures. **M. rectus lateralis** will be seen, with the **lachrymal** and **zygomatic nerves** coursing along its lateral aspect. The **abducens** nerve will be found entering the upper part of the middle of the rectus lateralis.

Just above M. rectus lateralis is **M. rectus superior**, and between them are the slender **anterior ciliary arteries.** Between the superior rectus and periorbital fascia is **M. levator palpebrae superioris.**

Is the last-named muscle present in the dogfish? (9)

Immediately deep to the upper part of the periorbital fascia is the **frontal branch** of the ophthalmic nerve. Find the **ophthalmic artery**, a large branch of the internal maxillary artery, leaving it close to the exit of the latter from the alisphenoid canal.

Identify the lachrymal gland, between the conjunctiva and the frontozygomatic ligament.

M. obliquus superior is anterior to M. rectus superior.

Does its tendon pass through a pulley as in Man?

Reflect M. obliquus superior, finding its nerve-supply. *Reflect* the upper bellies of the retractor oculi. The **ophthalmic artery** and the **infratrochlear** and **ethmoidal nerves** will be seen crossing above the optic nerve, the first named being nearest the eyeball, the last named farthest from it.

Do both of these nerves pass between Mm. rectus medialis and obliquus superior, as in Man? (10)

The **trochlear nerve** enters the lateral aspect of the superior oblique muscle close to the optic foramen.

Reflect M. rectus lateralis. The lower division of the oculomotor nerve passes superiorly to M. rectus inferior, to reach M. obliquus inferior.

Does this division of the nerve supply M. rectus medialis, as in Man? (11)

[*Reflect* the periosteum from the anterior orbital margin, near the opening of the nasolachrymal canal (cf. skull). The

Tongue and Lateral Pharyngeal Region.

Cut the internal maxillary artery and maxillary nerve near their exits from the skull. *Cut* the external maxillary artery, and the lingual nerve just below its junction with the chorda tympani. *Reflect* M. pterygoideus internus from the skull, and remove it completely. *Lay open* the vestibule of the mouth by cutting the cheek with the contained buccinator muscle away from the mandible, as far forwards as the first *premolar* tooth. With pliers *cut* across the mandible just behind this tooth. *Detach* the mylohyoid muscle from the hinder fragment of mandible. Separate the mylohyoid muscle from the mucous membrane of the mouth. Find the submaxillary duct (previously cut short), and along its course identify the rather diffuse **sublingual gland**, lying between the mylohyoid and styloglossus muscles. Follow the lingual nerve to the tongue.

> Is the course of the lingual nerve, relative to the submaxillary duct, similar to that found in Man? (13)

The hypoglossal and lingual nerves reach the lower margin of the styloglossus together, and disappear between the styloglossus and genioglossus muscles.

Distinguish the geniohyoid and genioglossus muscles. Examine the distribution of the hypoglossal nerve. Notice the relations of the styloglossus and internal pterygoid muscles to the cavities of the mouth and pharynx.

Reflect the styloglossus from the upper part of the anterior cornu of the hyoid, and cut it away from the main mass of the tongue.

Remove M. hyoglossus. Follow the lingual artery forwards. The **descendens hypoglossi nerve** leaves the

hypoglossal nerve near the origin of the lingual artery from the external carotid.

Cut the hypoglossal nerve near the tongue, and cut the external carotid artery near its bifurcation.

Superficial to the posterior cornu of the hyoid identify the **hyopharyngeus muscle (middle constrictor)**. At its hinder margin find the **internal laryngeal nerve**, crossing the posterior cornu of the hyoid after passing deep to the external carotid artery near the origin of the lingual artery. At the anterior margin of the hyopharyngeus muscle observe the **glossopharyngeal nerve** supplying M. hyopharyngeus and passing forwards to the tongue.

> Is its relation to the anterior cornu of the hyoid similar to its relation to the stylohyoid ligament in Man? (14)

Just behind the origin of the lingual artery from the external carotid are the origins of the **occipital** and **internal carotid arteries**. Compare the relations of the internal laryngeal nerve to these arteries in the dog and in Man. Notice the small size of the internal carotid artery.

The **external laryngeal nerve** and internal laryngeal nerve arise from a common stem, the **superior laryngeal nerve**, on the deep aspect of the occipital artery.

Re-identify the stylomastoid foramen and the facial nerve which emerges from it.

> How and where is the anterior cornu of the hyoid attached to the skull? *Detach* it and remove the upper segment (stylo-hyal). Re-examine the origin of the digastric muscle.

Examine the lateral muscles of the neck. Attached to the skull close to the stylomastoid foramen are the **sterno-**

mastoid and **cleidomastoid muscles.** Dorsally to these is a thin **cleidocervicalis**, and beneath it is the **splenius muscle.**

> What is the relation of the external jugular vein to the sternomastoid and cleidomastoid muscles?

The cleidomastoid covers the **common carotid artery, internal jugular vein** and the **vagosympathetic nerve.** Find the **accessory nerve**; it passes through the **cephalo-humeral muscle**, and is joined by a branch of the second cervical nerve.

> Does the accessory nerve supply the cephalo-humeral muscle? (15)

The accessory nerve passes backwards deep to M. cleido-cervicalis. The great auricular nerve arises from the second cervical nerve and pierces M. cleidocervicalis.

Detach the sternomastoid and cleidomastoid muscles from the skull. The internal carotid artery passes between the vagosympathetic nerve and pharyngeal branches of the latter.

> Does this artery enter the skull in a similar situation in Man and the dog? (16)

Close to the jugular foramen (for. lacerum posterius) the vagosympathetic nerve separates into distinct vagus and sympathetic nerves; identify the **superior (cranial) cervical ganglion**, and the **ganglion nodosum** lying alongside one another. (In the *rabbit* the vagus and sympathetic trunks are not united into a single nerve in the neck; further, a cardiac ['depressor'] nerve leaves the vagus opposite the larynx in the rabbit.)

> Where does the hypoglossal nerve leave the skull?

Find contributions from the cervical nerves to the ansa hypoglossi. *Define* the ventral margin of the **pterygopharyngeus muscle (superior constrictor)**, and the neighbouring margin of the hypopharyngeus. From the angle of the mouth, cut through the mucous membrane of the side-wall of the pharynx, between these muscles. The **epiglottis** will be seen, and in front of it a pair of depressions, the **valleculae**, separating it from the tongue.

What structures form the lateral relations of the vallecula? Compare the relations with those found in Man.

Find the **palatine tonsil**, just above and behind the last molar tooth of the mandible. *Remove* the pterygopharyngeus muscle completely, and define the cartilaginous portion of the Eustachian (auditory) tube. Cut open the side-wall of the nasopharynx (above the soft palate).

Has the soft palate a uvula, as in Man?

Identify the hinder margin of the nasal septum, and the opening of the Eustachian tube into the nasopharynx on the side opposite to that of the dissection.

Cranium and Nasal Fossa.

Remove the roof and side-wall of the cranium, on one side. Identify the cerebral hemisphere and olfactory bulb of this side, the **tentorium** and cerebellum. The lowest part of the cerebral hemisphere as seen in side-view is the **lobus piriformis** (much reduced in Man as the 'uncus').

Separate the upper margins of the two hemispheres, and *carry a knife* in the exact median plane through the whole brain; *detach* the exposed half of the brain from the spinal cord at the foramen magnum.

Remove this half of the brain, identifying the various cranial nerves as they pass from the brain to the cranial foramina.

Is there a **corpus callosum**?

Identify the **corpora quadrigemina**, **pons**, **optic thalamus**, **fornix**, **gyrus dentatus**.

The arrangement of the sulci on the surface of the cerebral hemisphere differs considerably from that of Man (and other primates). The area corresponding to the **insula** (of Reil) of the human brain is not submerged in a lateral (Sylvian) fissure in the dog. In the cat the arrangement of sulci is similar to that of the dog, but in the rabbit the hemisphere is devoid of sulci, apart from the **ectorhinal fissure** which bounds the lobus piriformis superiorly.

[Examine the courses of the middle and anterior meningeal arteries, and of the internal carotid artery. Identify the **transverse** and **cavernous sinuses**.]

Examine the course of the nasolachrymal duct, by removing the bone superficial to it with pliers.

Where does it enter the nasal fossa?

Remove the side-wall of the nasal fossa, observing the distinction between the olfactory portion and the **naso-pharyngeal canal** (which is below the body of the sphenoid. Identify the **ethmoidal conchae** (turbinals) and the **maxillary concha** (maxillo-turbinal).

Is there a maxillary air-sinus? (17)

Neck and Fore-limb.

The dissection is to be carried out on the same side as that of the head.

Incisions:

1. Mid-dorsal line, from the head backwards to the hinder end of the thoracic region.

2. Mid-ventral line, from the fore-end to the hind-end of the sternum.

3. Along the lateral aspect of the fore-limb, starting from a point opposite the shoulder on the skin-incision 2 of the 'head' dissection.

In the reflection of skin from the fore-limb notice the strong sheet of cutaneous musculature near the axilla. Care must be taken not to injure the **superficial radial nerve** which reaches the surface just proximal to the elbow on the lateral side.

Identify the **trapezius muscle**. Between it and the sternomastoid is the thin cleidocervical muscle, which will be seen to occupy nearly the whole region corresponding to the **posterior triangle** of the human neck.

Carefully reflect the cleidocervicalis without injuring the subjacent accessory nerve. The splenius muscle will be seen to pass caudally deep to the fore-end of **M. serratus ventralis**, which is comparable with M. serratus of the lizard (p. 67).

> Does the accessory nerve reach the trapezius muscle?

Detach the sternomastoid and cleidomastoid muscles from the skull and turn them towards the chest. Identify the transverse process of the atlas. Just dorsal to the common carotid artery is the **omocervicalis**[1] (omotransversarius)

[1] This muscle is occasionally found in Man.

muscle passing from the atlas to scapula. Ascertain its nerve-supply (18). Emerging dorsally to its hinder end will be seen large branches of the **transverse scapular artery**[1].

Deep cervical lymph-glands are situated around these vessels deep to the hinder part of M. omocervicalis.

[Rhomboideus capitis is a thin muscle-band extending to the skull from the scapula superficially to the splenius. Caudally it is deep to trapezius.

Reflect the splenius muscle. Its lateral margin overlaps **M. longissimus capitis**, with which it is closely united at the cranial insertion.

> Is the nerve-supply of splenius similar to that found in Man?

Detach longissimus capitis from the skull, exposing **semispinalis capitis**. This is to be detached in turn from the skull, exposing the **posterior oblique muscle**. (Contrast its relatively large size with that of the human 'inferior oblique'.)

> What are the attachments of the posterior oblique? Can you find any nerve comparable with the great occipital nerve of Man and the rabbit?]

The side of the **trachea** has been exposed by removal of the cleidomastoid muscle. Identify the **sternohyoid** and **sternothyreoid muscles**, on the ventral aspect of the trachea, and the branches of the **ansa hypoglossi** situated between them and the common carotid artery. Detach the cranial attachments of these two muscles. The **internal laryngeal nerve** enters the **thyreohyoid membrane**

[1] The main trunk of this artery is sometimes termed the 'omocervical trunk', on account of these large cervical branches.

close to the dorsal margin of the thyreohyoid muscle. Identify the **cricothyreoid muscle** and the external laryngeal nerve, which supplies it.

Just caudal to the cricothyreoid muscle is the right (or left) lobe of the **thyreoid gland**.

> Is it connected to its fellow by an isthmus, as in Man and the rabbit? (19)

On the dorsal surface of each lobe are the **parathyreoid glands**, of pinhead size, the one dorsal to the fore-end and the other dorsal to the middle.

Find the oesophagus, between the trachea and vertebral column. It is separated from the latter by the prominent **longus colli muscle**.

The oesophagus is attached cranially to the **crico-thyreo-pharyngeus** (inferior constrictor) **muscle**.

> How does the **recurrent** (inferior) **laryngeal nerve** enter the larynx? (20)

Cut open the pharyngeal side-wall in its whole length. Identify the aperture of the **larynx**, and the **pyriform recesses**.

The cleidomastoid and cleidocervical muscles are not attached to a clavicle in the dog, as they are in the rabbit, but form a single mechanical unit with the **cleidohumeral muscle** of the arm. A faint intersection in the compound muscle (the so-called 'cephalohumeralis muscle') indicates the site of the missing clavicle.

> What is the nerve-supply of M. cleidohumeralis, and what is the action of M. cephalohumeralis as a whole? (21)

Cut through omocervicalis, trapezius and rhomboid muscles close to their scapular attachments.

> Has **latissimus dorsi** a relation to trapezius similar to that seen in Man and the rabbit?

Deep to its anterior margin, find **M. teres major**, arising from the hinder margin of the scapula. Just anterior to the spine of the scapula is the thick **supraspinatus muscle.**

Separate the **long** and **lateral heads of triceps (anconaeus)**, reflect the **deltoid muscle** towards the humerus, and find the **axillary nerve** as it emerges from the **quadrangular space** to supply the deltoid, and teres minor[1].

Identify the **teres minor** and **infraspinatus** muscles. Cut the supraspinatus muscle from its scapular attachment.

> Where is it inserted? Is there any subacromial bursa?
>
> Does the **suprascapular nerve** pass through a scapular notch on the cranial margin of the scapula? (22)

Cut latissimus dorsi close to its vertebral attachment, and reflect it towards the axilla. Identify the hinder part of **M. serratus ventralis** and, ventrally to it, the **scalene muscle**, passing craniocaudally on the side of the thorax. The **thoracodorsal nerve** passes to latissimus dorsi between these two muscles. Find the nerve to serratus ventralis (the fore-part of this muscle corresponds to the levator scapulae of Man).

The **axilla** is a narrow space between the pectoral muscles and the latissimus dorsi (with associated cutaneous

[1] It has been stated in various text-books (*e.g.* Bradley) that it also supplies teres major and infraspinatus, but this is not found to be its normal distribution in the dog (*vide* also Tehver, J. *Anat. Anz.* **66**, p. 295, 1928).

musculature). There are two pectoral muscles, a superficial and a deep one, both attached to the humerus. Find their nerves (**ventral thoracic nerves**).

Identify the **phrenic nerve**. Observe that in the dog there is no scalene musculature ventral to the main trunks of the brachial plexus and subclavian artery, as there is in Man and the rabbit. The phrenic nerve enters the thorax ventrally to the **subclavian** and transverse scapular (omocervical) arteries.

The **inferior** (**caudal**) **cervical sympathetic ganglion** is separated from the phrenic nerve by the transverse scapular (omocervical) artery.

Examine the attachments of serratus ventralis.

> How do you think this muscle acts when the dog is in a standing posture?

M. coracobrachialis is relatively smaller than in Man.

> Where is it attached on the humerus?

The tendon of **M. subscapularis** passes between it and the shoulder-joint.

> Can you find a pectoral muscle attached to the coracoid process? (23)

The anterior blade of the scapula of the dog is unrepresented in that of a reptile such as the lizard.

> What muscles are attached to it (24) and what is their function?
>
> Do you think axial rotator movements of the humerus—of considerable extent—are possible at the shoulder-joint? What muscles control such movements? (25)

Identify the **ulnar nerve**. The **medial** and **lateral**

cords of the **brachial plexus** do not provide their contributions to the **median nerve** till they approach the **(ante)cubital space**. The various constituents of the **lateral cord**[1] leave the cord at various levels and do not form a single musculocutaneous nerve as in Man.

Observe that the **profunda**, the **anterior** and **posterior circumflex humeral** and the **circumflex scapulae arteries** arise from the **axillary artery** by a common stem.

Medial to the long (scapular) head of triceps is the **dorsiepitrochlearis muscle**. Find its nerve of supply from the **radial nerve**. The muscle arises from the edge of latissimus dorsi, and probably represents the **coracoid head of triceps (anconaeus)** of reptiles. In the rabbit[2] this muscle is much smaller. In Man it occurs only as an anomaly.

When the brachial plexus has been re-examined, the limb may be *detached* from the body.

The two 'extensor carpi radialis' muscles of Man are represented in the dog by a single muscle. **M. brachialis** has a humeral origin extending further proximally than in Man on the lateral aspect of the humerus. Between Mm. brachialis and **extensor carpi radialis** find the **radial nerve**, dividing into its superficial and deep branches, the former of which includes the nerve corresponding to the human N. cutaneus antibrachii dorsalis. M. brachioradialis is absent or at most represented by a vestige. M. brachialis forms a large lateral wall to the **(ante) cubital space**.

On which side of M. brachialis is M. cephalohumeralis attached? (26)

[1] The lateral cord itself is described sometimes as a 'musculocutaneous nerve' (*e.g.* Bradley, 1927, p. 131).

[2] The 'extensor antibrachii parvus' of Bensley and Krause.

[Deep muscles on the dorsal aspect of the forearm comprise **M. abductor pollicis longus**, whose tendon crosses that of extensor carpi radialis just proximal to the wrist, and **Mm. extensores pollicis longus** and **indicis proprius**. Their origins are covered by **M. extensor digitorum communis**. There are also small special extensors for the more lateral digits.

Compare the deep muscles of the dorsum of the forearm with those of Man.]

> Does the **deep radial nerve** pass deep to **M. supinator**? (27)

The **brachial artery** is continued in the forearm as the **median artery**. Its branches in the forearm have a different course from the 'ulnar' and 'radial' of Man, though they have been sometimes so described. In the dog, as in the rabbit, no large artery passes superficially to the insertion of **M. pronator teres** (as the human radial artery does). Detach M. pronator teres from the radius.

> Do the median nerve and artery pass through it or deep to it? (28)

In the cat the median nerve passes through an entepicondylar foramen.

The median artery gives off a large **interosseous artery**; the volar branch of the latter is far larger than the dorsal branch and passes distally deep to an extensive **M. pronator quadratus**, as will be seen in the subsequent dissection. (In the rabbit both pronator quadratus and the volar interosseous artery are wanting.)

Remove the deep fascia from the surface of the volar (flexor) forearm muscles.

The large superficial muscle in the middle of the flexor

aspect is **M. flexor digitorum sublimis**. Near the wrist the median nerve appears on its radial side, between it and **M. flexor carpi radialis. M. flexor carpi ulnaris** is represented by two muscles with humeral and ulnar heads of origin respectively.

Does the **ulnar nerve** pass between them?

Find the dorsal cutaneous branch of the ulnar nerve.

M. flexor digitorum profundus is a powerful muscle, which near the wrist will be seen deep to the median nerve.

Divide M. flexor digitorum sublimis and flexor carpi ulnaris, and turn them distally. M. flexor digitorum profundus has radial and ulnar heads as well as the humeral head of origin.

Is it supplied by both median and ulnar nerves?

There is no separate flexor pollicis longus, this being comprised in M. flexor digitorum profundus.

Does the latter provide a tendon to the pollex? (29)

The tendons of M. flexor digitorum sublimis are perforated by those of M. flexor digitorum profundus; they send slips into the callosities of the hand.

M. flexor digitorum profundus enters the hand by passing through a deeper osteofascial compartment than M. flexor digitorum sublimis, separated from the latter by a strong **transverse flexor ligament**. Divide this ligament.

How do the ulnar and median nerves travel through the wrist?

[At the distal margin of M. pronator quadratus find the volar interosseous artery. It is continued by a vessel which accompanies the ulnar nerve close to the pisiform bone,

and then turns across the hand to form the **deep volar arch**.

> Is the latter joined by a radial artery through the first intermetacarpal space, as in Man? (30)

Remove one-half of the large palmar callosity. Open up the mucous (synovial) sheath of the tendons of one of the digits, and follow the tendon of M. flexor digitorum profundus to its insertion. Notice the position of the terminal interphalangeal joint.]

> To which tendons are the **lumbrical muscles** attached? (31)
>
> Where does M. adductor pollicis take origin? (32)

Examination of joints.

> Does the tendon of biceps brachii pass through the shoulder-joint cavity?
>
> How do the insertions of Mm. brachialis and biceps in the forearm differ from those seen in Man?
>
> Is there an annular (orbicular) ligament at the proximal radio-ulnar joint, as in Man?
>
> Does the distal end of the ulna articulate directly with any carpal bone? (33)

Thorax and Abdomen.

The dissection to be carried out on the same side as that of the fore-limb. *Remove* the skin from the thorax and back, by means of mid-dorsal and mid-ventral skin incisions. *Remove* the remains of Mm. latissimus dorsi and serratus ventralis. Turn splenius caudally and *remove* it. The hinder part of its origin is overlapped by the thin aponeurotic origin of **M. serratus dorsalis anterior.** *Remove* this, observing the nerve-supply from intercostal

nerves. *Detach* the scalene muscle from the ribs, taking care not to injure the phrenic nerve. *Remove* Mm. pectoralis superficialis and profundus.

[Examine the **sacrospinalis muscle** in the lumbar region. As it passes into the dorsal region it divides into two parts, a lateral **iliocostalis** and a medial part which divides near the fore-end of the thorax into a more medial **spinalis** and a more lateral **longissimus dorsi**. **M. semispinalis capitis** (already dissected) emerges from beneath them in the interval between these muscles. Laterally to semispinalis capitis is the **longissimus capitis**. The latter is separated from the fore-end of longissimus dorsi by the **longissimus cervicis**.

Intercostal spaces. The **external intercostal** muscles do not extend ventrally in the region of the **costal cartilages**; the internal intercostal muscles are here visible.

Remove the external intercostal muscle of one space, and find the intercostal artery and nerve. Remove the internal intercostal muscle of the same space with care and expose the **costal pleura**.]

Cut through the costal cartilages of the first three ribs (the other side of the thorax not having been dissected) at their junctions with the ribs. Cut through the same ribs near their dorsal ends, and remove the fragments with adjacent intercostal structures and pleura. *If the other side of the thorax has been dissected previously*, remove instead parts of the second, third and fourth ribs, leaving the first rib intact.

The **pleural cavity** is thus laid open.

The **stellate ganglion** is situated close to the dorsal end of the second rib. It is just medial to the superior intercostal branch of the **costocervical artery**, and the con-

tribution of the first dorsal nerve to the brachial plexus. On the medial side of the ganglion is the hinder part of **M. longus colli**. The **sympathetic cord** extends caudally from the ganglion, in the angle between the necks of the ribs and the longus colli.

Find the **vertebral artery**. It arises in common with the costocervical artery from the subclavian artery. Remove the adjacent deep cervical lymph-glands. *Cut* off that part of the **anterior (apical) lobe of the lung** which is exposed, and examine the **mediastinum** (the septum between the two pleural cavities). Observe that the pleural cavity extends forwards close to the sternum, on the ventral side of the **internal mammary (internal thoracic) artery**.

The phrenic nerve is visible through the mediastinal pleura, passing medially to the internal mammary artery, and then (on the *right* side) between the pleura and the right **innominate vein** and anterior vena cava. On the *left* side there is no anterior vena cava in the adult (it is retained in the rabbit and pig) and the phrenic nerve runs somewhat ventrally to the **brachiocephalic artery**. On the *left* side the origin of the **left subclavian artery** from the aorta will be seen dorsal to the origin of the brachiocephalic artery from the **arch of the aorta**. Arising from the brachiocephalic artery, ventrally to the **trachea**, is the **left common carotid artery**.

On the *right* side, the vagus nerve will be seen dorsally to the phrenic nerve, on the lateral aspect of the trachea; on the *left* side it is near the left subclavian artery.

The **internal mammary (internal thoracic) vein** runs in a ventrodorsal direction in the mediastinum at the caudal margin of the **thymus**. It joins the beginning of the anterior vena cava. Caudally to this vein the mediastinum

is reduced to a thin membrane, as far as the **pericardium.** (In the *rabbit* the thymus extends caudally as far as the pericardium.)

Re-identify the **vagosympathetic nerve**, passing into the chest from the **caudal cervical ganglion**. It passes ventrally to the subclavian artery, and medially to the omocervical trunk, on the *right* side, but on the *left* side it passes dorsally to the subclavian artery, between it and the common carotid artery.

Right side. Three nerves leave the vagosympathetic nerve where it crosses the subclavian artery. One passes laterally to join the **stellate ganglion**. The other two leave as a single trunk which immediately divides into a **cardiac nerve** and a **recurrent laryngeal nerve**. The cardiac branch disappears dorsally to the anterior vena cava, the recurrent laryngeal nerve dorsally to the subclavian artery.

> Does the latter nerve pass dorsally to the right common carotid artery?

A nerve passes from the caudal cervical ganglion, dorsally to the vertebral artery, to the stellate ganglion.

Left side. The thoracic branch of the vagus to the stellate ganglion passes ventrally to the subclavian artery, and the cardiac and recurrent laryngeal branches do not leave the vagus till it reaches the arch of the aorta.

> Does the latter branch turn round to the dorsal aspect of the aorta, before passing forwards into the neck.
>
> How does the arrangement of the main arteries compare with that in the rabbit, the cat and Man?

On the right side the **vena azygos** joins the anterior vena cava just cranial to the root of the lung. This junction

represents the junction of the anterior and posterior cardinal veins of the embryo with the common cardinal vein (duct of Cuvier). Compare the relations of these veins to the vagus nerve with the relations seen in the dogfish.

The **pericardium** encroaches on the right side of the thorax about as much as on the left, unlike the human condition.

Reflect the **external oblique muscle** of the abdomen from the ribs, if it has not been already detached by the dissectors of the hind-limb. *Cut* through the cartilages of the ribs from the fourth to the eighth, and through the dorsal ends of the ribs, and remove them with attached intercostal structures. Ventrally the **costophrenic angle** is visible, where the mediastinal pleura joins the diaphragmatic pleura, but dorsally the pleural cavity extends considerably further in a caudal direction.

Identify the cut stump of the **apical lobe**, and the ventral (**cardiac**) lobe and posterior (**diaphragmatic**) lobe of the lung. Cut off these lobes near the root of the lung. Medially to the diaphragmatic lobe, the right lung has an **intermediate lobe**, which extends across the mid-line of the body dorsally to the **posterior vena cava**. Pull it out from the special recess of the right pleural cavity in which it lies. This recess separates a part of the *left* pleural cavity from the diaphragm.

> Is any part of the pericardial wall in contact with the diaphragm? (34)

The apex of the pericardium is united to the muscular part of the diaphragm by a tendinous band in the septum between the right pleural cavity and its intermediate recess (this band is wanting in the rabbit).

Separated by the intermediate lobe from the posterior vena cava is the **oesophagus**, with dorsodextral and ventrosinistral vagal trunks on its walls. At a later stage of the dissection it will be seen that each of these receives a contribution from both right and left vagi.

The two pleural cavities come into close relation in the narrow interval between the oesophagus and thoracic aorta.

Compare the relations of the oesophagus in the thorax, in Man and in the dog (or rabbit); compare also the mutual relations of the two pleural cavities.

The vena azygos extends caudally on the right side of the aorta.

Observe on the *left* side that there is only a slight cardiac depression in the lung, and that the mediastinum, between the heart and diaphragm, is displaced to the left of the mid-line owing to the presence of the intermediate recess of the right cavity. The left phrenic nerve passes through this part of the mediastinum.

The dissection of the thorax will be completed at a later stage, in conjunction with the dissectors of the other side of the body (p. 131).

Hind-limb.

If the *left* hind-limb has not been previously dissected, this one should be dissected.

Identify the following bony points:

Crest of the ilium, tuber ischii, great trochanter of the femur, patella.

Incisions:

1. From the crest of the ilium to the patella, and along the dorsum of the leg and foot.

2. From the proximal end of Inc. 1 to the side of the anus, passing medially to the tuber ischii.

3. Encircling the middle of the leg.

4. From the hinder end of Inc. 2 along the hinder border of the thigh and leg to meet Inc. 3.

Reflect the skin from the lateral aspect of the thigh and gluteal region, in a backward direction, starting from Inc. 1. Keep the knife very close to the skin in the region of the tuber ischii.

Reflect the skin from the medial aspect of the knee and thigh in a proximal direction from Inc. 3.

On the lateral aspect of the thigh the most conspicuous muscles are the **vastus lateralis** and **biceps femoris muscles**. The former covers the antero-lateral aspect of the thigh; the latter takes origin from the tuber ischii and from a **sacrotuberous ligament** and forms the postero-lateral surface of the thigh. (Just anterior to the origin of biceps, there is a small muscle in the *cat*, wanting in the dog, arising from caudal vertebrae and inserted by a slender tendon to the patella. In the *rabbit* this muscle, the **femorococcygeus**[1], is of enormous size, and is closely united to the anterior margin of the biceps. There is no sacrotuberous ligament in either of these animals.)

Cut through the strong fascia lata, in the interval between the biceps and vastus lateralis. Identify the **sciatic nerve**, deep down in the fascial space anterior to the biceps, and secure the N. cutaneus surae lateralis which leaves the sciatic nerve about the middle of the thigh and pierces

[1] Leche's term. This muscle has been frequently named 'caudofemoralis' (Parsons) or 'agitator caudae'. The former name is unsuitable since it has been extensively employed in describing another mammalian muscle (the caudofemoralis of Leche), which is absent in the dog, cat, rabbit, pig and Man (*vide* Appleton, *Journ. Anat.* 62, 1928).

M. biceps to reach the skin. The biceps forms the lateral wall of the **popliteal space**, where its hinder margin will be found to conceal a slender ribbon-like muscle, the **tenuissimus**. Separate the latter from biceps, working in a proximal direction.

Cut through the biceps, but not tenuissimus, just distally to the N. cutaneus surae lateralis, and turn the distal half towards the leg.

> How does the insertion of biceps femoris differ from that of the human muscle?
> Is the biceps muscle provided with a 'short head', as in Man?

Identify the **common peroneal** (external popliteal) and **tibial** (internal popliteal) **nerves**.

The popliteal space is deep, and has a medial wall formed by the **semimembranosus**, and at its hinder margin, by the **semitendinosus**. The terminal branches of the **posterior femoral artery** will be found supplying the muscular walls of the space.

Define the anterior margin of M. biceps femoris in the gluteal region. It overlaps the small **M. glutaeus superficialis (maximus)**; in the rabbit and cat the femoro-coccygeus intervenes. Anterior to the superficial gluteal muscle, the **glutaeus medius muscle** is superficial from the fore-part of the ilium to the great trochanter (in the rabbit it is concealed by the fore-part of the superficial glutaeus). Lateral to M. glutaeus medius, between it and vastus lateralis, is **M. tensor fasciae latae**. Define the anterior margin of the last-named muscle, where it is adjacent to the **M. sartorius anterior**.

Cut the superficial glutaeus muscle, at about its middle.

Turn the proximal half medially and find the **posterior gluteal nerve**, which enters its deep aspect.

> Is there any third trochanter present? A prominent third trochanter provides an insertion for the superficial glutaeus muscle in the rabbit.

Examine the lateral margin of the glutaeus medius near the great trochanter, and define the interval which separates it from **M. glutaeus minimus**[1].

Detach glutaeus medius from the great trochanter, reflect it from the ilium, and turn it medially. Find the **anterior gluteal nerve**, entering the glutaeus medius close to the **sciatic notch**. This nerve also supplies glutaeus minimus and tensor fasciae latae, passing superficially to the former to reach the latter.

> Does this nerve enter the M. sartorius anterior? (35)

Find the pyriformis muscle.

[The **posterior gluteal artery** reaches the proximal part of the biceps from under cover of the superficial gluteal muscle. Close to it is the **N. cutaneus femoris posterior**. This nerve passes deep to M. tenuissimus, in the *rabbit*, but in the dog it passes deep to the sacro-tuberous ligament and then turns round superficially to the origin of biceps from the tuber ischii. (In the rabbit the biceps is covered by a caudal head of semitendinosus proximally to the large sciatic vein.)

> Does the posterior gluteal artery pass deep to the thin proximal tendon of tenuissimus? (36) This tendon is attached to the aponeurosis on the deep aspect of biceps, and through this to

[1] Bradley's 'glutaeus profundus'.

the sacrotuberous ligament. Does the **nerve to biceps** pass superficially or deep to the tendon of M. tenuissimus? (37)]

Remove the fat and lymphatic gland of the popliteal space. Define the interval between Mm. biceps femoris and semitendinosus, find the nerve to the latter, and divide this muscle, exposing **M. semimembranosus**. Between M. semimembranosus and the vastus lateralis will be seen the **praesemimembranosus** and **adductor magnus muscles**, the former supplied like the semimembranosus by the **ventral sciatic nerve**, which also supplies semitendinosus and biceps.

The praesemimembranosus has a distal attachment similar to the 'ischiocondylar' part of the 'adductor magnus' of Man.

Divide both semimembranosus and praesemimembranosus, exposing the **gracilis muscle**, which is a broad muscle-sheet on the medial surface of the thigh.

Cut the sciatic nerve close to the sciatic notch, and turn it distally. Find the small **nerve to quadratus femoris** which disappears from view between Mm. glutaeus minimus and **gemellus anterior**. Caudal to the latter is the tendon of **obturator internus**, and behind this **gemellus posterior**. Proximal to the adductor magnus is the small **quadratus femoris**, the **medial femoral circumflex artery**[1] intervening.

Cut the tendon of obturator internus and the gemelli close to the femur, and turn them proximally.

Are they inserted on the femur in a similar situation to that seen in Man?

[1] The 'profunda femoris' artery of Bradley.

Turn forwards the hinder margin of the adductor magnus and find the **nerve to gracilis** (a branch of the **obturator nerve**) entering the gracilis.

Cut through the adductor magnus close to the femur, looking for the fascial plane which separates it proximally from **M. adductor brevis**. Distally to the latter muscle, the **adductor longus muscle** will be seen when the distal part of adductor magnus is reflected.

Observe that there is no caudofemoralis muscle comparable with that of *Necturus* and the lizard.

> How is retraction of the thigh effected in the dog?

Anterior Thigh Region.

Re-identify the anterior sartorius muscle, running along the anterior margin of the thigh.

> Where is it inserted distally? How does its action differ from that of the human sartorius?

Divide it near this insertion.

Deep to it will be found **M. rectus femoris**, and the **iliopsoas muscle** will be seen medially to the proximal end of the rectus femoris. Separate vastus lateralis and rectus femoris.

> Does the nerve to vastus lateralis pass superficially or deep to the rectus femoris? Is the relation similar to that seen in Man? (38)

The artery which accompanies the nerve to vastus lateralis is the **lateral femoral circumflex**.

Remove vastus lateralis (it is incompletely differentiated from the subjacent **M. vastus intermedius (crureus)**. Find the nerve to sartorius anterior, from the **femoral nerve**. *Cut* through the proximal end of rectus femoris,

and find the **nerve to M. sartorius posterior**. The femoral artery is situated in a **femoral triangle** (of Scarpa), just medially to the main stem of the femoral nerve. From this triangle it enters an **adductor canal**, bounded by **vastus medialis**, sartorius posterior and adductor longus, in company with the **saphenous nerve** and the nerve to vastus medialis (both branches of the femoral nerve).

Divide sartorius posterior and gracilis. *Cut* the structures occupying the adductor canal in the middle of the thigh, cut adductor longus, glutaeus minimus and quadratus femoris near the femur, and examine the attachments to the femur of iliopsoas and of the **obturator externus**, which is adjacent to the inferior aspect of the hip-joint.

Cut the femoral nerve and medial femoral circumflex artery. *Divide* the capsule of the hip-joint.

> Is there any powerful iliofemoral ligament, as there is in Man?

Cut the **ligamentum teres** of the hip-joint, and *detach* the limb from the body.

> Is there a lesser trochanter on the femur? (cf. pp. 60 and 75).

Follow the cut end of the medial femoral circumflex artery proximally. It disappears between the femoral artery and femoral nerve under cover of the muscular free margin of **M. obliquus externus**; its origin is from the **external iliac artery** within the abdomen.

> Is the lower margin of the external oblique muscle thickened as a tendinous inguinal ligament?
>
> Does any branch of the **obturator nerve** pierce the obturator externus as it enters the thigh?

Region of the Knee.

The saphenous nerve reaches the surface of the leg by passing between sartorius posterior and gracilis, accompanied by a **saphenous artery**.

> Are Mm. vastus medialis and vastus intermedius clearly differentiated from one another?

The femoral artery leaves the adductor canal between Mm. praesemimembranosus and adductor magnus to become the **popliteal artery**.

> Do you think this interval is comparable to the aperture through which the femoral artery passes in Man?

Notice the aponeurotic expansion passing from M. semitendinosus to the **tendo Achillis**.

Detach the medial head of **gastrocnemius** from the femur, noticing the sesamoid bone (**fabella**) close to its origin. Identify the tibial nerve. **M. plantaris** is exposed; it is one of the largest muscles of the leg. Separate it from the lateral head of gastrocnemius.

> Can you find a soleus muscle? In the rabbit the soleus is very small, arising from the proximal end of the fibula (and not from any part of the tibia).

Find the **medial sural cutaneous nerve**, arising from the tibial nerve in the popliteal space.

Just above the ankle, examine the interval between the tendo Achillis and the tibia. A large tendon, that of **M. flexor digitorum longus**[1] occupies a groove on the posterior aspect of the tibia. On the *medial* side of the **medial malleolus** two tendons pass through a groove; the

[1] See note 1, page 117.

smaller is that of **tibialis posterior**, the larger that of **M. flexor hallucis longus**[1].

Cut the tendon of flexor hallucis longus and turn the muscle proximally. The vestigial tibialis posterior muscle is deep to it. Medial to the proximal ends of these muscles is **M. popliteus**.

By moving the knee-joint, ascertain the probable function of this muscle. (39)

The **popliteal artery** terminates by passing **deep** (anterior) to the upper margin of the popliteus muscle, beyond which it is continued on the front of the interosseous membrane as the **anterior tibial artery**. At the proximal border of the muscle the popliteal artery gives off a very small posterior tibial artery.

How does the course of the popliteal artery differ from that of Man?

M. peronaeus longus is situated between the flexor digitorum longus (which is behind it) and the extensor digitorum longus. Follow its tendon into its groove on the **lateral malleolus**. Notice that the groove is on the *lateral* aspect, not behind the malleolus. The peroneal nerve passes deep to this muscle, and as the dissection proceeds examine its distribution.

Deep to M. peronaeus longus is **M. peronaeus brevis**, whose tendon passes *behind* the lateral malleolus. Between these two peronaei is a small **M. peronaeus digiti quinti superior**[2] (rarely found in Man), whose thin tendon ac-

[1] The names 'flexor digitorum longus' and 'flexor hallucis longus' are used in the contrary sense by Bradley. The muscle to which Bradley applies the latter name acts predominantly on the digits other than the hallux, and is thus more appropriately termed 'flexor digitorum longus'.
[2] The 'extensor digiti quinti' of Bradley.

companies that of peronaeus brevis on the malleolus and eventually joins the extensor longus tendon of the fifth digit. Immediately anterior to this muscle, and arising also from the fibula, is the vestigial **extensor hallucis longus**, whose tendon accompanies the anterior tibial artery and **deep peroneal** (anterior tibial) nerve to the front of the ankle. The peroneal nerve divides into superficial and deep divisions, but the former is accompanied by a nerve-bundle destined for **M. extensor digitorum longus**.

The deep peroneal nerve is deep to the tendon of **M. tibialis anterior** at the ankle.

Examine the proximal attachment of M. extensor digitorum longus.

> How does it differ from that seen in Man? The cat and rabbit are in this respect similar to the dog. How do you think the difference affects its functions?

Follow the **plantaris tendon** distally. It is not attached to the tendo Achillis but passes round the tuber calcanei (where there is a synovial sheath) and is continued into the **plantar aponeurosis**.

Find the **medial plantar nerve** immediately to the medial side of the aponeurosis.

The tendon of M. flexor hallucis longus joins that of flexor digitorum longus in the foot. The slender tendon of tibialis posterior ends in the **deltoid ligament**.

On the lateral side of the sole of the foot, a small **quadratus plantae** joins the flexor digitorum longus tendon, arising on the fore-end of the calcaneus.

Remove the medial half of the great sole-pad. Reflect

the plantaris aponeurosis distally. It ends in a series of tendons each of which encircles a tendon of flexor digitorum longus opposite the head of a metatarsal, and is inserted into the second phalanx. Small **flexor digitorum brevis**[1] muscles pass from the plantaris tendons of the third and fourth toes to join those of the flexor digitorum longus. Between the plantaris tendons of these toes a small cutaneous tendon passes from the tendon of M. flexor digitorum longus to the great sole-pad. Pull this cutaneous tendon and observe the movement of the sole-pad.

Deep to the flexor brevis muscles will be found the division of the flexor digitorum longus tendon, and three **lumbrical muscles** passing from it to the three lateral toes. Find the division of the tibial nerve into **medial** and **lateral plantar nerves**, and follow the latter between the plantaris aponeurosis and the tendon of flexor digitorum longus. At the lateral margin of the foot it turns medially under cover of (dorsal to) the **adductor (contrahens) muscle** of the fifth digit. It passes medially between a more superficial muscle-layer, the contrahentes (adductores) and a deeper layer of **interossei**.

The anterior tibial artery is continued in the foot as the dorsalis pedis artery.

> Through which intermetatarsal space does it gain the sole of the foot?
>
> Does the tendon of M. peronaeus longus cross the sole of the foot as in Man?

Cut the tendon of extensor digitorum longus, and find M. extensor digitorum brevis.

[1] Described by Bradley as 'tendinous slips'.

Knee-joint. *Divide* the capsule of the joint on each side of the patellar tendon, and open the joint. Cut through the patellar tendon just below the patella, and identify the **anterior cruciate ligament.** *Extend* the incision medially, cutting through the **tibial collateral ligament.**

> Is the **medial meniscus (semilunar) cartilage** attached to the ligament, as in Man?

Extend the incision laterally, dividing the tendon of extensor digitorum longus. *Cut* the tendon of **popliteus** which is between the **fibular collateral ligament** and the **lateral meniscus**, and the part of the joint-cavity which is below the meniscus is revealed.

Cut through the anterior cruciate ligament, and open the joint widely by acute flexion. The **posterior cruciate ligament** is thus exposed. The lateral meniscus has its main posterior attachment on the femur, this connection being represented in man by the 'ligament of Wrisberg'.

> Is the shape of the cavity of the knee-joint similar to that of the human knee-joint?

Ankle-joint. *Divide* the tendons of peroneal muscles.

Strong **posterior talofibular** and **calcaneofibular ligaments** pass from the fibula to the tarsus.

> What is attached to the notch on the postero-medial aspect of the fibula?

Reflect the tendons of flexor hallucis longus and tibialis posterior from the groove on the medial malleolus. The deltoid ligament is attached distally to the **navicular**, to the **sustentaculum tali** and to the **talus (astragalus).** *Divide* this ligament.

What articulates with the triangular facet on the infero-medial aspect of the head of the talus? (40)

Are there any movements of inversion and eversion between the talus and subjacent tarsals, as in Man?

Posterior Abdominal Region.

This dissection should be carried out on the same side as that of the hind-limb.

Remove the skin from one side of the abdominal region, with the assistance of mid-dorsal and mid-ventral incisions.

Identify the longitudinally-placed **rectus abdominis.** Dorsally to the M. obliquus abdominis externus is the **sacrospinalis**. Detach the external oblique muscle from the ribs and fascia covering sacrospinalis and turn it ventro-medially. It is continuous with a thin aponeurosis forming the ventral wall of the rectus sheath.

Inguinal canal. The thin aponeurosis of the external oblique muscle is attached caudally to the pubis. Emerging from the aponeurosis, on the ventral aspect of the rectus muscle, will be seen the **spermatic cord** (in a *male*); in the *female* there emerges a mass of fat surrounding the **round ligament of uterus**. The opening in the aponeurosis is the **subcutaneous inguinal ring**.

From this opening the spermatic cord passes laterally in the **inguinal canal** covered by the external oblique aponeurosis, along the lower free margin of the **obliquus abdominis internus**, as far as the **abdominal inguinal ring**, where it passes through the transversalis fascia

(which lines the inner aspect of muscular wall of the abdomen).

> Is there a falx inguinalis, providing the internal oblique and transversalis muscles with an attachment to the pubis, as in Man?

The internal oblique muscle is continuous medially with an aponeurosis which passes ventrally to M. rectus abdominis and is attached to the tendinous intersections of that muscle. Cut this aponeurosis near the lateral margin of M. rectus abdominis, and cut its strong attachment to the costal margin. Reflect the internal oblique muscle dorsally. It is attached dorsally to the lumbodorsal fascia, covering sacrospinalis. Deep to this muscle is **M. transversalis**. Its aponeurosis passes deep to M. rectus abdominis, forming the dorsal wall of its sheath.

Find the **deep (posterior) epigastric artery**. It passes deep to the spermatic cord at the lateral margin of the rectus muscle, and then cranially deep to that muscle.

> Does it pass medially to the abdominal inguinal ring, as in Man?

If the opposite side has been *already* dissected, examine the interior of the peritoneal cavity from that aspect before proceeding with your own dissection.

Cut through the **linea alba**, uniting the ventral walls of the rectus sheath, and through the peritoneum. Reflect the rectus abdominis from the hinder part of the thoracic wall. Make an incision through the transversalis muscle along the costal margin and through the subjacent peritoneum.

On the *left* side, the **descending colon** will be seen dorsally, extending along the side of the psoas major muscle.

Ventrally to it is the fat-laden **great omentum**. Near the pelvic cavity, ventrally, is the **bladder**, which is connected to the ventral body-wall by a ventral mesentery. Turn the great omentum forwards carefully, without tearing it. The **small intestine** is thus exposed. If this is lifted forwards, a deep **rectovesical pouch** will be seen between the bladder and the colon and fore-part of the **rectum**. This pouch is bounded on each side by a peritoneal fold, the paravesical fold, containing in its free margin the **obliterated hypogastric artery**.

In the *female*, a **cornu** of the **uterus** will be found medially to the dorsal end of each paravesical fold, between it and the hinder part of the colon, suspended in a **broad ligament**. From this ligament another peritoneal fold extends to the abdominal inguinal ring, containing the round ligament of the uterus.

The peritoneal pouch enclosed between the broad ligaments on the ventral aspect of the rectum is the **recto-uterine pouch (pouch of Douglas)**.

The uterine cornu is continued forwards beside the colon as a **uterine (Fallopian) tube**, also suspended by the **broad ligament**. Medially to this part (**mesosalpinx**) of the broad ligament, between it and the colon, is the **external iliac artery**. The psoas major muscle is lateral to this artery.

At the fore-end of the uterine tube, identify the hinder pole of the **kidney (metanephros)**. Medially to the fore-end of the tube is the **ovary**.

In the *male*, identify the **ductus (vas) deferens**, passing from the abdominal inguinal ring on the medial side of the **ureter** to the dorsal aspect of the bladder (where it enters the prostatic urethra with its fellow).

Pelvic Region.

Removal of the Os coxae.

Clear away the remains of gluteal and thigh muscles. *Cut* the muscles of the abdominal wall away from their attachment to the iliac crest. Turn the cut end of the iliopsoas forwards, and detach the origin of the iliac part of this muscle from the os coxae. Deep to it will be seen the tendon of the **psoas minor**, attached to the pubis near the symphysis. Cut this, and find the **obturator nerve** deep to it. Carry the knife round the medial aspect of the fore-end of the ilium, detaching sacrospinalis.

Deep down in the interval between the tail and tuber ischii there is a considerable mass of fat, lying at the side of the **rectum**. This fat occupies the **ischiorectal fossa**. Find the sacrotuberous ligament, and the N. cutaneus femoris posterior; medio-ventral to the latter is the **pudendal nerve**.

The **(ischio)coccygeus muscle** extends from the caudal vertebrae to the ischium, passing beneath the sacrotuberous ligament, and concealing the hinder part of the rectum. Divide the ligament and the coccygeus.

> Does the pudendal nerve enter the ischiorectal fossa anterior or posterior to the ischial attachment of coccygeus?
>
> Is there any 'spine' on the ischium at this attachment?

Cut through the symphysis pubis with pliers. By forcing the tuber ischii laterally and ventrally, the os coxae can now be dislocated from the sacrum. *Before* it is completely separated, examine the distribution of the pudendal nerve, and identify the **obturator internus muscle**, covering the medial aspect of the obturator foramen. On pulling the

os coxae away from the rectum, the **levator ani muscle** (**ilio-pubo-coccygeus**) will be seen extending dorsally at the side of the rectum, and attached to the pelvis and fascia covering the obturator internus along a line extending from opposite the acetabulum to a point near the pubic symphysis. Divide this muscle.

Cut the **crus penis** (or crus clitoridis of the *female*) and the **ischiocavernosus muscle** away from the ischiopubic arch.

The os coxae can now be *detached* from the body.

Identify the hinder end of the **bladder**, and the **urethra**, which is situated ventrally to the rectum. Between the urethra and rectum, in the *female*, is the **vagina**.

Open the side-wall of the vagina. At its hinder end it will be seen to turn sharply in a ventral direction to become continuous with the **urogenital canal** (vestibule). *Open* this canal. The deep **fossa clitoridis** will be seen on the anterior wall of the vestibule, near the **vulva**, while more dorsally on the anterior wall will be found the opening of the urethra into the canal.

Carry the incision in the vaginal wall forwards, through the **external os** of the **uterus**, and lay open the cavity in the body of the uterus. Find the openings of the uterine cornua into the body. In the *rabbit* there are two uteri with separate openings into the vagina.

In the *male* identify the **prostate** surrounding the urethra, just behind the bladder.

> Can you recognise a urogenital diaphragm, similar to the human one?

Follow the vas (ductus) deferens of this side from the spermatic cord to the urethra.

> Can you see any seminal vesicles? (41)

Follow the ductus deferens into the scrotum. Identify the **epididymis**, **testicle** and **tunica vaginalis**.

> Does the tunica vaginalis communicate with the general peritoneal cavity? (42) It does so in the rabbit.

Abdominal Cavity and Pericardium.

This dissection is to be carried out *jointly* by all the dissectors of the animal. The *left* side of the animal should be examined first. The greater parts of the second to the eighth ribs on this side have been already removed. *Carry the knife* along the attachment of the diaphragm to the succeeding ribs, and remove these ribs.

Under cover of the dorsal parts of the last two ribs is the **spleen**. Between this and the liver will be seen a part of the stomach. Observe that the great omentum is hollow, and that the spleen is attached to its left-hand wall. The lumen of the great omentum is a part of the **omental bursa**.

Dorsally to the spleen, in the dorsal wall of the great omentum, is the **body of the pancreas**. Identify the **splenic artery** and its branches to the stomach.

> Does the dorsal pole of the spleen touch the kidney? (43)

Observe that the great omentum separates the stomach from the small intestine.

> Is this the condition in Man also?

Identify the **central tendon of the diaphragm**.

> Is the liver connected to the ventral body-wall by a **falciform ligament**?

Find the gall-bladder. It projects from a deep fissure in the **central lobe** of the **liver**. To the left of this central lobe is the large **left lateral lobe** of the liver. Cut off this lobe. A small lobe of the liver will be seen lying in the concavity of the lesser curvature of the stomach If this is examined carefully it will be seen that a thin membrane, the **lesser (gastrohepatic) omentum** (extending from the stomach to the liver) covers this **omental lobe**.

Cut off the greater part of the great omentum, with the spleen, but leaving the pancreas undisturbed. The lumen of the omental bursa is thus opened, and by looking dorsally to the stomach the omental lobe of the liver can be seen lying within the omental bursa. Dissect now from the *right* side.

Remove the remains of the thoracic wall on this side. The liver will be seen to lie in contact with the right kidney. The small lobe of the liver, bearing a deep concavity in which the kidney fits, is the **caudate process**. Cut this off, and then cut off the main mass of the right lateral lobe.

> Has the liver any bare area, in contact with the diaphragm, as it has in Man? (44)

Identify the **posterior vena cava**, and, in the right margin of the lesser omentum, the **bile-duct** (ductus choledochus). Between these structures there is a passage leading from the general peritoneal cavity into the omental bursa, the **epiploic foramen (of Winslow)**. Its cranial wall is formed by the liver, while in its caudal wall is the hepatic artery; as it passes from the dorsal aspect of the omental bursa to the lesser omentum, this artery is in the **mesoduodenum**.

> Has the duodenum a mesentery in the rabbit also?

Accompanying the bile-duct in the lesser omentum will be seen the **portal vein** and **hepatic artery**. The union of the **cystic** and **hepatic ducts** is readily seen at the cranial end of the bile-duct. The portal vein is formed by the union of the **gastrosplenic** and **common mesenteric veins**, in the lesser omentum. The whole length of the **duodenum** has a mesentery in which is found the **right lobe** (**head**) of the **pancreas**. On the left side of this mesentery it will be found to have fused with parts of the **mesenteries** of the **small intestine**, of the **transverse colon**, and of the **descending colon**.

Examine the junction of the small intestine and colon. A short **caecum** is adherent to the surface of the terminal part of the small intestine. (In the rabbit the caecum is of relatively enormous size and terminates in an appendix.) The **ascending colon** will be found adherent to the meso-duodenum.

Observe that the peritoneal cavity extends dorsally to the fore-part of the right kidney. Dorsally to this space is the caudal margin of the diaphragm.

The right suprarenal is placed between the anterior pole of the kidney and the posterior vena cava.

> Which kidney is the more cranially situated? In the cat and rabbit the right is the more cranially placed.

Follow the hepatic artery dorsally. Half an inch from the aorta it joins the common trunk of the **left gastric** and **splenic arteries**, forming the **coeliac axis**. Find the right **coeliac ganglion**, close to the junction of the coeliac axis and aorta. The **right crus** of the diaphragm has the posterior vena cava on its ventral aspect and the coeliac axis on its left side.

Dissecting again from the *left* side, find the cut end of the splenic artery. Just caudal to the coeliac axis is the **anterior mesenteric artery**. Just caudal to the origin of this artery from the aorta will be found the **anterior mesenteric ganglion**, overlapped by the posterior vena cava. Just caudal to this artery will also be found the **left renal vein**. Examine the caudal margin of the diaphragm, dorsal to the left kidney.

> Is there a definite lumbocostal arch such as one sees in Man?

Just dorsal to this margin of the diaphragm will be found the site of separation of the **great splanchnic nerve** from the **sympathetic cord**.

Follow the great splanchnic nerve round the caudal margin of the diaphragm. In the dorsal abdominal wall it turns abruptly medially to reach the **suprarenal ganglion**, which is just dorsal to the **suprarenal**. From this ganglion nerves will be seen to pass to the anterior mesenteric and coeliac ganglia.

Identify the **posterior mesenteric artery**.

> Which part of the alimentary canal is supplied from it?

Observe that the dorsal mesentery of the stomach is continuous with the wall of the great omentum.

> Is any part of the left kidney found in the dorsal wall of the omental bursa? (45)

Tie a ligature round the rectum, and *cut* through the rectum on the cranial side of the ligature. *Cut* through the oesophagus close to the stomach and through the mesentery with its contained vessels, also the lesser omentum with its contained vessels.

The gut can now be removed. Slit it up and examine its interior after washing.

> Can you see any **Peyer's patches** in the ileac part of the small intestine?

Cut open the caecum and adjacent part of the colon, and examine the ileocaecal valve.

Find the renal arteries, and the origins of the external iliac arteries from the aorta. A little caudal to the latter will be found the origins of the **hypogastric (internal iliac) arteries** from the abdominal aorta.

> How does the origin of the hypogastric arteries in Man differ from that seen in the dog?

Re-identify the femoral nerve. It emerges from the substance of the iliopsoas close to the inguinal ligament. Observe that the iliopsoas is not distinctly differentiated into psoas major and iliacus muscles.

> What is the relation of the obturator nerve to these muscles? (46)

Find the **N. cutaneus femoris lateralis.**

> Does either the iliopsoas or the psoas minor extend in a cranial direction dorsally to the hinder margin of the diaphragm? (47)
>
> Which is the largest branch of the hypogastric artery?

Examine the course of the ureter from the kidney to the bladder.

Pericardium and Heart.

Re-identify the pericardio-diaphragmatic ligament. No part of the pericardial wall is in contact with the diaphragm. *Remove* a part of the left wall of the pericardium. The **left ventricle of the heart** is seen, with its covering of serous pericardium. Ventral to the left ventricle will be seen a small part of the **right ventricle**. In the groove between them the **left coronary** artery passes towards the apex of the heart. At the dorsal end of the interventricular groove is the **appendix** of the **left atrium**; the pulmonary artery and aorta are situated between this appendix and the appendix of the right atrium.

Lift the apex of the heart forwards. There is only a small **oblique sinus** of the pericardium dorsally to the heart; it is placed between the **left posterior pulmonary vein** and the **posterior vena cava**.

The **transverse sinus** is a small passage passing forwards and to the right between the left atrium and the pulmonary artery.

Dissect from the *right* side. *Open* this side of the pericardium, and find the right-hand end of the transverse sinus passing between the anterior vena cava and aorta. The aorta and pulmonary artery are thus encircled by the pericardial cavity. Cut both of these vessels close to the heart, cut through the posterior vena cava, pulmonary veins and anterior vena cava. *Remove* the heart. Observe that the anterior vena cava, right pulmonary artery and trachea are situated dorsally to the transverse sinus.

Find the **ligamentum arteriosum** (a remnant of the fœtal **ductus arteriosus**).

On which side of it does the recurrent laryngeal nerve pass?

The right cardiac branch of the vagus has been already identified in the thorax. Follow it to its destination in the cardiac plexus. Examine the mode of formation of the two vagal trunks on the oesophageal wall from branches of the right and left vagi.

The heart. Wash out the cut ends of the pulmonary artery and aorta and examine the **semilunar valves**.

Open the right atrium, cutting through from the anterior to the posterior vena cava. Identify the **intervenous tubercle** (of **Lower**), and the **musculi pectinati.**

The opening of the **coronary sinus** is ventral to the opening of the posterior vena cava, between the latter and the **tricuspid valve**. (In the rabbit the left superior vena cava enters the right atrium in a corresponding situation.)

Identify the **fossa ovalis.**

Cut off the apex of the heart, wash out the ventricles and examine the tricuspid and **mitral valves**; notice the **musculi papillares** and **chordae tendineae.**

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ANSWERS TO QUESTIONS

Petromyzon (or **Entosphenus**). 1. Yes. 2. In front of the papilla. 3. Similar to the dogfish, but unlike the rabbit. 4. Yes, but it is very short, being restricted to the fore-end of the liver. 5. Yes, but it is very incomplete, being represented merely by the part that contains the bile-duct, portal vein and hepatic artery. 6. Neither are present as definitive organs. 7. All are present, but the conus arteriosus is not readily distinguishable on external examination. 8. Dorsally. 9. Yes. 10. No. 11. Yes, restricted to the hinder end, forming the 'tectum synoticum'. 12. No. 13. Two. 14. No.

Squalus. 1. No. 2. No. 3. No. 4. No. 5. Yes. 6. Superficially. 7. No. 8. No. 9. No. 10. No, the nerve to the medial rectus is incorporated in the inferior division of the nerve in man. 11. Great superficial petrosal. 12. No. 13. Through its antero-inferior margin. 14. Transbasal vein, connecting the orbital sinuses. 15. Yes. 16. Yes. 17. Yes. 18. Dorsally. 19. Medially. 20. No. 21. The hypobranchial artery. 22. Two, the contribution from the more caudal of these is small. 23. Yes. 24. No. 25. Yes. 26. No. 27. Yes. 28. No. 29. Lateral. 30. In the horizontal myoseptum.

Necturus. 1. The ventral (or flexor) aspects. 2. No. 3. No. 4. Two on each side. 5. No, in the dogfish it is effected by hypobranchial musculature. 6. From the efferent artery of the first gill. 7. The lateral epicondyle. 8. Ventrally. 9. Ventrally. 10. Yes. 11. There is a septum transversum, separating the pericardial from the pleuroperitoneal cavity, but there is no muscular diaphragm. 12. No. 13. No.

Lacerta. 1. No. 2. No. 3. Yes. 4. No. 5. The ophthalmic nerve passes forwards on the medial side of the epipterygoid, while the maxillary and mandibular nerves pass laterally behind it. 6. It arises from the *right* aortic arch. 7. No, for the mammalian rectus femoris is lateral to pectineus (*e.g.* in Man). 8. No.

Canis. 1. Mainly between scapula and chest-wall. 2. No. 3. 3rd upper premolar. 4. Facial only. 5. Paroccipital process of occipital bone. 6. No, it does not pass forwards in the pterygoid region superficial to them. 7. No. 8. Yes. 9. No. 10. Yes. 11. Yes. 12. Fascia covering M. pterygoideus internus. 13. Yes. 14. No. 15. Yes. 16. No; in the dog the internal carotid artery enters the carotid canal behind the auditory bulla, within the jugular foramen. 17. There is a small one. 18. Cervical plexus (C. 2, 3, 4, 5). 19. There is an isthmus only in certain individual dogs. 20. Between the cricoid and thyreoid cartilages, dorsally to their articulation. 21. The nerve-supply is from the 6th cervical nerve, through a stem in common with N. suprascapularis; M. cephalohumeralis advances the forelimb, movement occurring between scapula and chest-wall. 22. No. 23. No. 24. Supraspinatus and subscapularis are attached to the greater part of its surface. 25. Subscapularis and infraspinatus. 26. On its lateral side. 27. Yes. 28. Both pass deep to pronator teres. 29. Yes. 30. No. 31. That of flexor digitorum profundus. 32. From the carpus and interosseous muscle of the second digit. 33. No. 34. No. 35. No. 36. Yes. 37. Deep. 38. Yes. 39. Medial rotation of the leg, at the knee-joint. 40. Plantar calcaneonavicular ligament. 41. No. 42. Yes. 43. Yes. 44. No. 45. No. 46. The nerve is medial. 47. Psoas minor has such an extent, but not the iliopsoas.

INDEX

Pages **1–6** refer to the dissection of the Lamprey: **7–39** to that of the Dogfish: **40–62** to that of *Necturus*: **63–76** to that of the Lizard: **77–132** to that of the Dog.

The more important references are indicated by heavy type.

A

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Reference: *Lamprey*, pp. 1–6; *Dogfish*, 7–39; *Necturus*, 40–62; *Lizard*, 63–76; *Dog*, 77–132

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N

Reference: *Lamprey*, pp. 1–6; *Dogfish*, 7–39; *Necturus*, 40–62; *Lizard*, 63–76; *Dog*, 77–132

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